BY AIRPLANE TOWARDS THE NORTH POLE

1/12/31

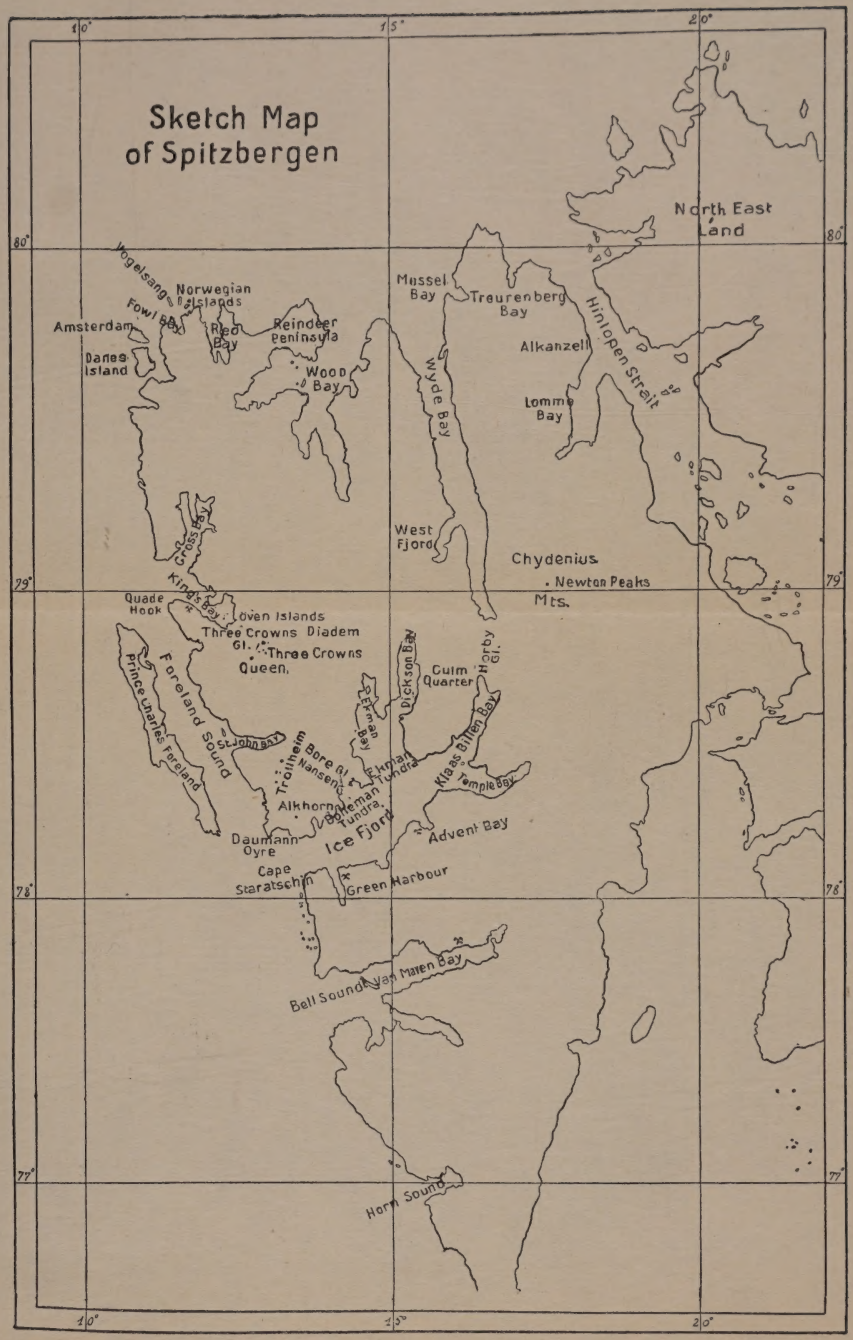
RY OF
COMPANY

M THE SHELVES
AMISSION OF
BRARIAN

REFERENCE LIBRARY * HOUGHTON MIFFLIN CO. * BOSTON, MASS.
Archive
Collection

This book may not leave the Offices
and if borrowed must be returned within 7 days

BY AIRPLANE TOWARDS THE NORTH POLE


Sketch Map
of Spitzbergen
10°
15°
20°
80°
79°
78°
77°
North East
Land
Vogelsang
Norwegian
Islands
Fowl Bay
Amsterdam
Danes
Island
Red
Bay
Reindeer
Peninsula
Wood
Bay
Mussel
Bay
Treurenberg
Bay
Hinlopen Strait
Alkanzell
Lomme
Bay
Wyde Bay
West
Fjord
Chydenius
Newton Peaks
Mts.
Cross Bay
Kings Bay
Quade
Hook
Oven Islands
Three Crowns Diadem
Gl.
Three Crowns
Queen
Foreland Sound
Prince Charles Foreland
St John Bay
Trollheim
Bore Gl
Nansen
Ekman
Tundra
Lerner
Bay
Dickson Bay
Gulm
Quarter
Horby
Gl.
Klaas Billen Bay
Temple Bay
Alkhorne
Boheman
Tundra
Ice Fjord
Advent Bay
Daumann
Oyre
Cape
Staratschin
Green Harbour
Bell Sound
Van Mijen Bay
Horn Sound

By Airplane towards the North Pole

AN ACCOUNT OF AN EXPEDITION TO SPITZBERGEN IN THE SUMMER OF 1923

BY

WALTER MITTELHOLZER

Lieutenant in the Swiss Airforce

AND OTHERS

WITH FORTY-EIGHT ILLUSTRATIONS AND FOUR MAPS

Translated from the German by
EDEN & CEDAR PAUL

BOSTON AND NEW YORK
HOUGHTON MIFFLIN COMPANY
1925

Printed in Great Britain by
UNWIN BROTHERS, LIMITED, LONDON AND WOKING
(*All rights reserved*)

PREFACE

I HAVE much pleasure in acceding to the request of the Junkers Works that I should write a few prefatory words to the account of the remarkable aviation enterprise to Spitzbergen recently promoted by the firm.

Modern inventions in the form of land-surveying instruments have greatly facilitated the art of cartography. By a combination of the use of the stereophotographic method with that of the familiar instruments of precision, almost perfect results can be obtained. A yet further advance has been secured by the use of airplanes for cartographical purposes. Now that it has been found practicable to draw maps in accordance with the data of stereophotographs taken from airplanes, we are entitled to say that this method of cartography has achieved finality alike theoretically and practically. Furthermore, the technique of aviation has reached a very high level of development, and the most suitable flying conditions are adequately known as far as the greater part of the globe is concerned. The exception, hitherto, has been the arctic and antarctic regions, the most remote and the least

accessible regions of the world. Last summer, the Hammer expedition, using an airplane supplied by the Junkers Works, was able, by its brilliantly successful flights in Spitzbergen, to make a valuable contribution to our knowledge of polar aviation. In especial I must refer to the circular flight made from Green Harbour round the northern half of Spitzbergen, and extending northward beyond the eightieth parallel of latitude. The flight passed across the open sea, across wide glaciers, and across the waters (filled with drift ice) adjoining the eastern and northern coasts of Spitzbergen. This flight, and the admirable photographs taken during its course, have shown beyond question that, henceforward, airplanes will be indispensable to circumpolar exploration, and that their use will revolutionise this branch of scientific research.

ADOLF HOEL.

CHRISTIANIA UNIVERSITY,
April 11, 1924.

TABLE OF CONTENTS

PAGE

PREFACE 5

LIST OF ILLUSTRATIONS 9

LIST OF MAPS 10

INTRODUCTION, by PROFESSOR KURT WEGENER . . . 12

GENERAL CHARACTERISTICS OF THE EXPEDITION . . . 13

SPITZBERGEN 20

Paths of the Heavenly Bodies 20
The Moon 22
Aurora Borealis 23
Temperature 24
Vegetation 24
Snow 25
Land Surface 26
Ocean Currents 27
Pack Ice 28
Fjord Ice 29
Thickness of the Ice 30
Fog 31
Aerology 32
Geology 36
Fjord Formation 38
History 41
Whale-Fishery 41
Seal-Fishery 44
Fishers and Hunters 44
Coal 47
Ores and Marble 51

PAGE

AIMS OF AIRPLANE PHOTOGRAPHY 53

WHAT CAN BE LEARNED FROM THE PHOTOGRAPHS . . 57
Cartography 57
Glacier Formation 58
Denudation 61
Advantages of Airplane Views 62

PHOTOGRAPHY FROM AIRPLANE, by PROFESSOR A. MIETHE 65

GEOGRAPHICAL VALUE OF THE PHOTOGRAPHS, by CAPTAIN H. BOYKOW 81

THE FIRST ARCTIC AVIATORS, by AIRFORCE LIEUTENANT WALTER MITTELHOLZER 93

FOREWORD 95

EN ROUTE 99
An Unexpected Proposal 99
Hamburg to Hesnaes by Seaplane 102
Hesnaes to Christiania via Copenhagen . . . 107
Three Days in the Norwegian Capital . . . 108
The Members of the Expedition Foregather in Bergen 109
Voyage up the Coast of Norway 112
A Change of Plan 115
Tromsö and its Surroundings 116
Crossing the Barents Sea 123

IN SPITZBERGEN 127
First Impressions 127
The Seaplane and its Equipment 129
A Friendly Call by Airplane 132
A Trial Trip 134
Advantages and Drawbacks of Arctic Aviation . 139
Midnight Sunshine and Wintry Summer . . . 140
A Foggy Day 141
Second Trial Trip 142
The Main Flight 147
A Lame Duck 171

ENVOY 176

LIST OF ILLUSTRATIONS

		TO FACE PAGE
1.	TROMSÖ FROM THE NORTH-EAST	46
2.	VIEW SOUTHWARD FROM THE TROMSDALSTIND	46
3.	PANORAMA FROM THE TROMSDALSTIND LOOKING TOWARDS THE NORTH-WEST	47
4.	HUT FIFTY METRES ABOVE THE WIRELESS STATION	47
5.	WIRELESS STATION OF GREEN HARBOUR	54
6.	YMER HARBOUR WITH THE ESMARK GLACIER AND THE VERMLAND RANGE	55
7.	THE MEMBERS OF THE EXPEDITION	60
8.	DUTCH COALMINES IN GREEN HARBOUR	60
9.	MOUNT PROTECTOR-ALKHORN	61
10.	THE ESMARK GLACIER	61
11.	THE MITTAG-LEFFLER GLACIER	72
12.	THE HORBYE GLACIER	73
13.	THE EDGE OF THE WAHLENBERG GLACIER	96
14.	THE BORE GLACIER WITH MOUNT SYLTOPPEN	96
15.	VIEW TO THE NORTH-WEST FROM THE TROLLHEIM PLATEAU	97
16.	EKMANN BAY AND DICKSON BAY WITH THE ANDRÉE QUARTER	97
17.	THE KONOW GLACIER WITH THE LÖWENSKIOLD PLATEAU, FROM THE SOUTH-WEST	104
18.	MOUNT HOLTA WITH PRINCE CHARLES FORELAND, FROM THE NORTH-EAST	105
19.	THE DALSLAND RANGE WITH THE TROLLHEIM PLATEAU, FROM THE SOUTH-EAST	110
20.	THE NORDENSKIÖLD GLACIER IN BILLEN BAY, FROM THE WEST	110
21.	VIEW FROM THE HOLTEDAHL PLATEAU TOWARDS THE SOUTH-WEST	111
22.	THE WESTERN SHORE OF DICKSON BAY	111
23.	FAIR HAVEN, FOWL GLACIER, AND MOUNT VESTERALEN, FROM THE NORTH	116
24.	FAIR HAVEN, THE RIGHTWARD CONTINUATION OF THE LAST	117

		TO FACE PAGE
25.	The Firn Plateau, looking Northward	122
26.	The Firn Plateau, looking Southward	122
27.	The Bore Glacier	123
28.	A Slightly Different View of the Bore Glacier	123
29.	Chydenius Mountains, from the East	128
30.	Cross Fjord and King's Fjord, with Prince Charles Foreland, from the North	129
31.	Newton Peaks, looking Westward	134
32.	Mount Dauman and Mount Lex, looking North-Westward	134
33.	North East Land, looking Southward	135
34.	The North-Western Corner of North East Land, looking North-Eastward	135
35.	Norwegian Islands, Fowl Island, and Amsterdam Island, looking South-Westward	138
36.	Fowl Island and Amsterdam Island	139
37.	Brögger Peninsula	144
38.	Lomme Bay, from the South	144
39.	Lomme Bay, from the South-East	145
40.	Lomme Bay, from the North-East	145
41.	Broad Bay, from the East	150
42.	The Eidem Glacier	151
43.	Pack Ice in Hinlopen Strait	156
44.	Pack Ice in Hinlopen Strait, another View	156
45.	North-Eastern Coast of Western Spitzbergen	157
46.	Pack Ice in Hinlopen Strait, a Third View	157
47.	Red Bay, from the West	162
48.	Cross Bay with Quade Hook, from the North	163

LIST OF MAPS

1.	Spitzbergen	*Frontispiece*
2.	Fowl Bay	*Page* 86
3.	Hinlopen Strait	„ 87
4.	Lomme Bay	*End of book*

INTRODUCTION

By PROFESSOR KURT WEGENER

GENERAL CHARACTERISTICS OF THE EXPEDITION

THE expedition described in the present work originated as an accessory outgrowth to Amundsen's plan to fly across the Pole from Point Barrow in North America. In the drafting of this scheme there was a miscalculation, and it transpired that Amundsen would never be able to reach Spitzbergen with the supplies of fuel his airplane was competent to carry. The upshot of this was that, at the instigation of Consul Hammer of Seattle (one of Amundsen's personal friends), the Junkers Works sent a small flying expedition to Spitzbergen. The purpose of this expedition was to fly from Spitzbergen northwards across the ice-pack, and upon this ice-pack to make a cache of necessaries at the spot Amundsen was expected to reach, thus facilitating the explorer's crossing of the Polar Circle. The accessory expedition would have had a difficult task, for the site of the cache would have been liable to move rapidly, the drift of the ice-pack under the influence of the wind being sometimes as much as twenty knots

in twenty-four hours. When, therefore, Amundsen fortunately changed his plan, after the members of the expedition had already crossed the arctic circle, they promptly decided to use the plane for photographic researches in Spitzbergen. This book contains a compendium of the results.

The personnel of the expedition was as follows. 1. The before-mentioned Consul Hammer, whose services were of inestimable value in facilitating relationships with the Norwegian authorities and business firms. 2. Walter Mittelholzer, lieutenant in the Swiss airforce, whose photographs from airplane in the Alps are well known. Lieutenant Mittelholzer took all the cinematographic pictures and ordinary photographs secured during the expedition. 3. Air Pilot Neumann, who was throughout responsible for the care of the Junkers airplane. He brought it safely, in part by flight and in part by marine transport, from Dessau to Spitzbergen and back; and he was in charge of all the flights made during the expedition. 4. Air Mechanic Holbein, whose only luggage on the voyage to and from Spitzbergen was a small handbag containing a repairing outfit. In Holbein's opinion, obviously, his airplane engine was by far the most important thing in the world. Although this was the first time he had ever left home, neither the lovely fjords and craggy peaks of Norway, nor the

sinister icebound landscapes of Spitzbergen, nor yet the exceptionally good feeding upon the journey, could console him if anything were lacking for his beloved machine. 5. Works Foreman and Air Pilot Duhs, who spoke Danish fluently, and was therefore of especial use as interpreter during the work of lading and unlading in Bergen, Tromsö, and Spitzbergen. 6. W. Löwe, as representative of the Junkers Works. 7. The present writer, Kurt Wegener, who was attached to the expedition in an advisory capacity upon the recommendation of Dr. Hergesell.

The airplane was of the ordinary Junkers type fitted with floats and snow runners. No use could be made of the runners, because we came too late in the summer. The advantage of having floats was that our resources could be husbanded, and, owing to the haste with which the expedition had been despatched, these were rather scanty. There is also much greater risk of injury when the start and the landing have in every case to be made from the solid ground. A seaplane runs far less danger on these occasions. Unless an extensive cross-sea flight is being made, the seaplane makes considerably less claim upon the skill and attention of the airman. Of course, the carrying capacity of the seaplane is less, and the seaplane has less climbing power.

As I have already explained, we made a very

hurried start, the need to reach Spitzbergen being urgent. In the circumstances, therefore, it was impossible to have a perfect equipment. All the more remarkable is it, therefore, that a number of successful flights were made, and that a convincing demonstration could be given of the advantages of airplane work when the aim is to secure a general view of a country, to study the face of the earth with all its wrinkles and crow's-feet, and to take bird's-eye views which can be used for scientific elaboration. For economic reasons, it was necessary to take a great many film pictures, which could be utilised for cinematographic reproduction. These had to be taken at short range, from a plane flying low down between the mountain peaks, in order to give vigorous movement to the series of pictures. These moving pictures of mountain tops never yet trodden by the human foot could not be obtained without great dexterity and resolution on the part of pilot and photographer, but they naturally have little value for scientific purposes.

The main technical achievement of the expedition was that it demonstrated the practicability, with the aid of two good weatherproof (all-metal) and well-engined airplanes and a simple photographic equipment, of mapping out the western island within the course of a single summer. A very wide-meshed Steinmann-triangulation

sufficed as the basis of the cartographical work. It is necessary to issue a warning against the use of unsuitable (wooden) machines. If the aviators are forced by bad weather to land in some quiet fjord, such a machine, covered with snow and ice, will very probably be unable to fly any further when the weather conditions improve. In these circumstances, the landing may prove a catastrophe.

Within the compass of the present volume it is impossible to give a detailed account of the scientific study of Spitzbergen. A great many scientific expeditions have been made to these islands. Sir W. Martin Conway, in his *No Man's Land* (Cambridge, 1906), gives a faithful and unbiased account of the work of earlier investigators. The story of the chief expeditions has been related in independent monographs. I need refer to a few only of the explorations previously made. Starting from Mussel Bay, Parry attempted to reach the Pole with sledges, but failed owing to the impassability of the pack ice. From the same point, Nordenskiöld designed to march northward with sledges drawn by reindeer, but his expedition met with a series of mishaps, one of which was that all his reindeer excaped during a snowstorm. While the explorers were wintering in Mussel Bay, during a great storm in January the ice broke up and the ship narrowly escaped being driven ashore. At

this time, during the middle of the polar winter, the sea was free from ice as far as the eye could reach. Two expeditions, one Swedish and one Russian, wintered simultaneously in Treurenburg Bay and Horn Sound, respectively, the object being the measurement of an arc of the meridian along the west coast. In the winter of 1882–3 a Swedish meteorological station was established at Cape Thordsen in Ice Fjord for carrying on the observations designed by the International Polar Committee.

There have also been innumerable summer trips to Spitzbergen, some preparatory to expeditions farther afield, some recreative, and some on behalf of sport or inspired by commercial aims. Many of these summer visitors have made their way into Hinlopen Strait or to North East Land or to Prince Charles Foreland. Hitherto, however, only the west coast has been adequately mapped. In this region the work of Isachsen has been continued by annual Norwegian expeditions under the leadership of Hoel. The area lying between Ice Fjord and Wyde Bay has often been explored, but has not been mapped. The same remarks apply to the district between Ice Fjord and the east coast. I have myself marched from King's Bay to Wyde Bay and back, making sketches and taking bearings by the compass. Nordenskiöld crossed North East Land during the winter expedition already

mentioned. In all such journeys the greater part of the traveller's energies are engrossed by the toils and hardships of the undertaking. I took three weeks to travel with sledges from King's Bay to Wood Bay, thence by Graa Hook to Wyde Bay, and back to King's Bay by way of the West Fjord. The whole distance of 320 kilometres (200 miles) could be covered by airplane in three hours. A sledge journey of this kind is an unceasing struggle for bare existence. The travellers, to whom every ounce of weight is a serious consideration, have to go on short rations. At night, the explorer shivers in his sleeping-sack. By day, he is blinded by snow-storms and fog. Even in clear weather his vision is bounded by the nearest snow-mound. His thoughts are much less concerned with the nature of the country through which he painfully makes his way, than with the nature of the white death which threatens him on all hands and from moment to moment. I think that every one who has wandered afoot through this desert of snows, must have longed at times for wings, that would enable him to soar above the country—that would enable him, above all, to see !

SPITZBERGEN

SPITZBERGEN lies between the northern parallels 76° 50′ and 80° 50′. King's Bay is only 1,200 kilometres (750 miles) from the Pole, and this distance could be covered by airplane in ten hours.

Paths of the Heavenly Bodies.—In these high latitudes the course of the stars is different from that with which we are familiar. If we were at the Pole, the sun would make its appearance on the horizon towards the middle of March. From then to the middle of June it would gradually screw itself in a narrowing spiral to a higher altitude in the sky, declining after the same fashion, now in a widening spiral, until the middle of September. From mid-March to mid-September there is continuous daylight, the light of the six months' polar day; and from mid-September to mid-March there is continuous darkness, that of the six months' polar night. During the customary diurnal period of twenty-four hours, the sun would describe a circle round the observer stationed at the Pole. Throughout such a circuit, it would remain at approximately

the same altitude in the sky. The highest altitude attained by the sun is at midsummer, being then 23.5°.

During the polar night the moon would appear on the horizon during the first quarter. As it increased to the full it would screw upwards in spiral fashion, to screw down once more when waning, and to disappear on the horizon in the last quarter. Like the sun, it would circle round the observer once every twenty-four hours, remaining at approximately the same altitude throughout this period. In Spitzbergen, at latitude 79°, and therefore 11° from the Pole, the sun circles in similar fashion during the polar day; but at midnight, when it norths, it is 11° nearer the horizon, and at noon, when it souths, it is 11° nearer the zenith.

Until the middle of October the sun continues to rise for a brief period daily in Spitzbergen, and then disappears altogether for four months. When the longed-for orb once more greets those who have wintered in this far northern region, its daily visits are at first very brief. Day by day, however, it gains a greater altitude in the southern sky, and the days rapidly lengthen, until by the middle of April the sun no longer dips below the northern horizon at midnight, but now makes a complete circuit of the sky, The four months' summer day has begun.

The Moon.—The course of the moon through the skies at Spitzbergen is correspondingly different from that which would be visible to an observer at the Pole. During the lunar month of about 29½ days, the moon remains above the horizon for 10 days. While waxing, it makes the whole circuit of the sky, screwing itself up continually higher; and while waning it declines along a similar spiral. For the four days before and the four days after the ten days of persistent visibility, the moon rises for a few hours daily. Thus there are ten to eleven days in the lunar cycle during which there is, in winter, complete darkness except for starlight and the aurora. If the weather is favourable at the times when the moon is above the horizon, hunting and other fresh-air exercises are practicable, and this gives a wholesome relief during the long polar night. But if bad weather prevails during the second and third quarters of the lunar cycle, the hardships of wintering within the arctic circle are greatly intensified. It is true that the lurid streamers of the northern lights may at times give an illumination brighter than that of the moon, so that the moon then ceases to cast shadows; and the aurora shines at its own wayward pleasure, whatever phase the moon may happen to be in. But the northern lights are fitful and untrustworthy.

Aurora Borealis.—The northern lights that are visible during the polar night in Spitzbergen lie, as the observations of the German observatory in Spitzbergen during the winter of 1912–13 showed, almost exclusively between Spitzbergen and Norway. The illuminant region in the atmosphere ranges from a height of 70 kilometres (44 miles) to a height of 250 kilometres (155 miles). Two Norwegian scientists, Birkeland and Störmer, have given an experimental and mathematical demonstration of the cause of the aurora. It consists of cathode rays, which emanate from the sun just like the rays of ordinary sunlight. When they enter the earth's magnetic field, these rays are deflected, to an extent which varies in accordance with their velocity, in the direction of the magnetic lines of force. Impinging upon our atmosphere, they give rise to the northern lights, doing so with the greatest intensity where the lines of force are most thickly concentrated.

Observers with a poetical turn of mind are fond of describing the glorious colouring and the brightness of the northern lights. In reality we are concerned here with optical illusions. In the persistent darkness, the pupil is greatly expanded, and the eye is readily dazzled by a very faint illumination. Spectrum analysis shows that the light of the aurora consists mainly of green rays, with a moderate intermixture of blue.

If the weather happens to be bad during the four ten-day periods of what should be moonlight just within the arctic circle, the result may be disastrous alike to man and beast. The fate of those whose ships are caught in the ice, and who must perforce winter in these latitudes, will often be decided by the weather conditions shortly before and shortly after full moon.

Temperature.—During the four months' winter night the earth receives no warmth from the sun. If the weather is clear, there is no hindrance to radiation, and the temperature may fall to −40° (40 degrees of frost Centigrade, and 72 degrees of frost Fahrenheit). When there is a warm wind from the south-west, and when radiation is checked by the cloudiness of the skies, the temperature even at midwinter may rise to freezing point, and rain may actually fall. Of course the water freezes as soon as it touches the frozen and snow-covered ground.

Vegetation.—During the summer season, no considerable rise in temperature is possible, owing to the universal presence of ice, or water only just above the freezing-point. But in sheltered nooks, within the deeply cut fjords, the sun can warm the ground sufficiently for the growth of vegetation to be possible. Here mossy carpets and Alpine meadows form, and the gloom of the

frozen and craggy slopes is mitigated by verdure and by a predominantly Alpine vegetation. But none of these plants venture to raise their heads to any considerable height. All of them must snuggle close to the ground, the only source of warmth, where they can get a little protection from the icy blasts, and escape being dried up by the wind. There are no shrubs or trees in Spitzbergen. A dwarf "tree," the polar willow, does indeed grow in these regions; but its twigs remain hidden beneath the moss, above which only its leaves project a little. Thus its total height is only two inches. Whatever may succeed in blooming during July and August, is soon cut down by the return of the polar night.

Snow.—In June, the winter snows begin to melt, and soon the land emerges here and there from beneath its white pall. Hitherto only the larger rocks and the mountain peaks with their gloomy declivities have been disclosed; all the rest has been wrapped in snow. Now the areas free from snowy covering spread rapidly. By the beginning of July, the snows have vanished from the greater part of Spitzbergen, except where the glaciers fill the mountain valleys. Snow may fall at any time, but in the height of summer this new-fallen snow speedily melts. Such is the course of events until September, but by then the land has begun to cool down below

freezing-point once more, and the sun's rays are no longer powerful enough to melt the snowfall. The white pall of winter spreads once more athwart the land. By degrees, the inequalities of the surface disappear beneath the snows, but it is not until February passes into March that we see a practically unbroken snow-sheet—a paradise for the skier.

Land Surface.—The ground is frozen to a depth of about 300 metres (1,000 feet), and the summer thaw extends to a depth of about 1 metre (3 feet) only. The result is that the surface water (derived mainly from the melting of the snow) cannot, as in our latitudes, percolate through the strata to emerge ultimately in springs and flow seaward in rivulets and rivers, but saturates the most superficial stratum, whence the excess flows off without percolation. This leads to the formation of impassable swamps and tundras.

The summer snow-line in Spitzbergen is at an elevation of 300 metres (about 1,000 feet). Above this altitude there is perennial ice and snow. The only difference between summer and winter is that, in summer, pools and runnels form on the glaciers, that crevasses appear, and that the glaciers calve more frequently whenever they extend down to the sea. When this calving takes place, the sound is like the rolling of

distant thunder. The icebergs thus formed in the Spitzbergen fjords are, however, puny, when compared with those of western Greenland.

Ocean Currents.—The land is cooled by radiation more rapidly than the adjoining sea. Therewith the air in contact with the land surface is likewise cooled, so that it becomes heavier than the air out at sea, and sinks seaward to form the fairly constant chill mountain wind that blows down the glaciers and the fjords. All the polar continents and archipelagos are, from the meteorological outlook, high-pressure areas. The descending cold air, which in the valleys has had its direction given by the shape of these, becomes free upon reaching the sea, and now its path is determined by the law of inertia. Like Foucault's pendulum, it tends to continue upon its course, while the earth spins beneath it. In the northern hemisphere it takes an apparent twist to the right, circling the continent or archipelago in which it has originated. Although this movement is in many cases masked or compensated by other atmospheric forces, there is still manifest a dominant trend, disclosed above all by the movement of the surface waters of the sea. By friction, these surface waters become involved in the prevailing movement of the air, to this extent, that when the air moves 100 yards, the surface water moves about 1 yard in the same

direction. When the water is covered with ice, the friction is greater, and then the drifting movement is doubled, to become 2 yards of water drift for every 100 yards of movement in the air. The net upshot is that all the polar continents and archipelagos are surrounded by ocean currents which, in the northern hemisphere, move clockwise, so that along the eastern side of the land cold water and ice run southward, and along the western shore the current is towards the north. That is why the western and north-western coasts of Spitzbergen are especially accessible. Along the eastern shore, on the other hand, the masses of drift ice move southward as far as the southernmost point, and round this towards the west and north. In years when there is more ice than usual, Horn Sound and Bell Sound may be blocked with ice for almost all the summer. Sometimes even Ice Fjord will have its mouth temporarily blocked with ice during parts of July, August, and September, the three months when there is least ice in this region. Farther north, where the drift ice has melted, the presence of the cold current is shown by belts of fog.

Pack Ice.—Northward of the north coast of Spitzbergen lies the pack ice which covers the polar basin in summer as well as winter. When the wind is southerly, the pack is blown well

away from the coast, so that it is sometimes possible to sail as far as the North Cape of North East Land without seeing any ice. But when the wind sets from the north, the ice pack moves southward; and ships that have taken refuge in the bays may be shut in by the ice, and compelled to winter in Spitzbergen. Wood Bay and Wyde Bay are usually closed by the ice in September.

Fjord Ice.—In the fjords the water begins to freeze towards the end of September. The wide-mouthed fjords, however, get cleared of ice from time to time throughout the winter. This happens in the following way. At spring tide, that is to say when the moon is new or full, the high tide breaks the ice along the edges, and a moderate breeze seaward will drive it all out to sea. During the winter of 1912–13, it more than once happened to us when marching on the fjord ice (it is about three feet in thickness, and is greatly preferable as a road to the almost impassable ice-covered rocky slopes), that the ice would begin to break up, fissures forming in it and rapidly widening. We had promptly to make for the shore, which was not always easy to reach. Half an hour later, there would be no ice left in the fjord. Of the best-known bays, Wyde Bay is firmly frozen over from the end of October till the end of June. So is Wood Bay.

The bays in the north-west are always untrustworthy. The winter ice in Cross Bay can only be depended upon as far as King Haakon Mountain; that in King's Bay is trustworthy as far as the Loven Islands. In Ice Fjord, owing to the currents, the ice cannot be relied upon until December; at the inner extremity of this bay, the ice does not break up until the end of June or the beginning of July, and the mouth of the bay is liable to be blocked with ice at any time. The inner part of Bell Sound is frozen from October till the middle of July. Thus in Spitzbergen for from eight to ten months in the year the line of demarcation between land and water, which forms the basis of insular cartography, is indeterminate. Until the end of May, the bay ice is good for snow-shoe travel. Then the surface thaw begins. Every grain of dust that has fallen upon the snowfield, warmed by the rays of the sun, melts a hole for itself in the snow; this hole grows continually deeper and wider; and, after a time, with the spreading of these "dust-scars," an impassable mass of slush forms.

Thickness of the Ice.—The pack ice of the polar basin, which impinges on the northern coast of Spitzbergen, forcing its way into Hinlopen Strait and along the east coast of North East Land, may, through riding of the layers one upon the

other, attain a thickness of more than 10 metres (33 feet), but the bay ice and the recently formed drift ice has an average thickness of only 1½ metres (5 feet). Bay ice and drift ice form smooth plains, which may become a little arched by mutual pressure where the floes come in contact. Pack ice, on the other hand, consists of superimposed layers and irregularly agglomerated fragments, interspersed with floes of drift ice and open channels (leads or lanes).

The pressure which makes the floes ride one on another, and thus gives rise to the formation of pack ice, can only occur where there are considerable areas of open water, so that the wind can set the great ice-sheets in motion. On the free coasts of Spitzbergen, such pressure areas frequently occur. In Hinlopen Strait often, and in the fjords occasionally, riding of the floes will also result from the action of the tides, the rise and fall of which in these parts is about 5 feet, producing vigorous currents.

Fog.—In general, seamen regard the polar region as the home of fogs, but Spitzbergen is not much afflicted. July to October is the foggiest season, but even throughout this period there will be no more than about ten foggy days. The cause of fog has been studied and elucidated. Mist forms when air charged with moisture streams over a cold surface. That is why there

is so much fog along the edge of the ice-field, and on the west coast of Spitzbergen, where the cold current previously described flows northward along the coast.

Aerology.—A still commoner phenomenon is a lowering of the cloud stratum in which the mountain tops are wrapped. Owing to the frequency of this occurrence, aviation is only possible in Spitzbergen during a few days of each month. But the cloud masses are localised, as a rule, being found where the wind impinges upon the coast.

To leeward, and on fine days, Spitzbergen is the aviator's paradise. The velocity of the wind rarely exceeds ten metres a second (twenty miles an hour). Whereas in our latitudes there is usually a stronger wind aloft than on the ground level, we seldom find this in Spitzberzen. Moreover, at moderate altitudes the temperature is often rather higher than upon the surface of the earth. The atmosphere is extraordinarily free from dust, so that splendid views to immeasurable distances can generally be had.

It was natural, therefore, that the notion of aviation in these high latitudes should soon arise. Andrée, the Swedish aeronaut, was the first to realise the idea, though not at his date in a heavier-than-air machine. His plan was to cross the north polar region in a balloon which should

be rendered in some degree dirigible by the use of sails and trailing ropes. When making preparations for the aerial voyage, which was to start from Danes Island, Spitzbergen, he found that the direction of the prevailing winds was unfavourable, and he ceased to believe in the possibility of success. Still, he made the attempt, starting with two companions on July 11, 1897. It had been arranged that buoys containing news should be dropped by the aeronauts, and two of these buoys were subsequently found, but they dated only from the day of the ascent. A carrier pigeon despatched thirty hours after the start brought later news—the last that was heard of the ill-fated expedition. The balloon had drifted eastward instead of northward, and the end of the voyage probably occurred in the sea to the west of Nova Zembla. Andrée, prizing fame more than life, died attempting the impossible. Wellman, an American, starting from the same place as Andrée, set out in a motor balloon on what was little more than an advertising stunt. This expedition came to an end within sight of the starting-point. Count Zeppelin designed to make aerial explorations with Spitzbergen as base, but the scheme, whose foundations were laid with great care, was frustrated by the outbreak of the war. First of all came a summer visit to Spitzbergen, where experiments were made with a captive balloon; and the problems

of building an airship shed, of establishing a gas-plant, and the like, were considered. In 1911, Zeppelin and Hergesell founded what was intended to be a permanent meteorological station in Ice Fjord. Here the aerological conditions were studied by the use of kites, by free balloon ascents, and by the installation of registering instruments in captive balloons.

In 1912 the station was removed to Cross Bay, and here I built a house, and passed the winter of 1912–13. In the autumn of 1914, after the outbreak of war, the station was abandoned. Meanwhile, however, an understanding had been arrived at between the Zeppelin-Hergesell expedition and the Norwegian Meteorological Institute, and by the terms of this arrangement the observations were to be continued. The station was transferred to Quade Hook, on the opposite shore of the fjord, the remains of the old observatory being utilised in the building of the new houses. The reason for the change of site was that a coalmine was now being worked to the eastward of Quade Hook.

While we were in Spitzbergen, the new Norwegian observatory became the stage of the last act in a Spitzbergen tragedy. The director of the station, Dr. Stoll, driven out of Alsace because of the war, had entered the Norwegian service, and had now passed three successive winters at the observatory. In the winter of 1921–22 he

sent two of his staff, in a boat well stocked with provisions, to search for a lost seal-hunter. These two men never came back. Stoll sent wireless messages to Norway, whence rescue expeditions were despatched, but without result. Then, in 1923, some Norwegian aviators (a Norwegian expedition to meet Amundsen had been sent out simultaneously with our own), camping in Cobbe Bay, North West Spitzbergen, found, quite by chance, the bodies of the two missing men. They had left a written record which showed that their boat had been ice-bound during the winter of 1921–22. Ultimately they made their way to the land in Cobbe Bay, but did not know where they were. They took refuge in a cave, unaware that there was a sealer's hut close at hand. They did not put up any signal, for navigation is so dangerous in winter that they had no expectation of an attempt at rescue before the summer. In actual fact, the steamer that was in search of them entered Cobbe Bay while the men were still living. Stoll himself was in the crow's nest, anxiously scanning the shore for a sign of them. After the vessel had already put about, and when Stoll's attention was concentrated upon the other shore, one of the unfortunates caught sight of the departing vessel. He called his companion, and together they shouted at the tops of their voices, fired shots, waved their arms, did everything they could to attract

notice. Their food would last them only another week. If they failed to make their presence known to those on the steamer, they were doomed. But inexorably the ship continued on its course; their cries and gunshots were unheard, their frantic gesticulations unheeded. Despair overwhelmed them as the ship vanished, for now the only prospect was the death that dogs the heels of all who venture far within the arctic circle—death by hunger, cold, and exhaustion. Meanwhile the rescue expedition went on searching the coast, inlet by inlet, and almost stone by stone, while Stoll hoped and feared, but was not to know until many months later how near he had been to the objects of his search.

In the summer of 1923, when the bodies were found, and the details were revealed by the diary which had been kept by the abandoned men, the director's nerve gave way. His morale had already been undermined by three years spent in this desolate spot. He was overwhelmed with self-reproach for misadventures on whose score no one else would have dreamed of reproaching him. Thus the arctic island which had been his second home, became his permanent resting place.

Geology.—If we are to harmonise the data of geology with those of cosmography and seismology, we must assume that the plates which form

the continents swim upon the surface of the denser interior of the earth much as ice-floes swim upon the surface of the sea. The transmission of earthquake waves shows that the interior of the earth is markedly stratified, and that as the centre is approached the density increases, not gradually, but by jumps. Whereas the specific gravity of the densest rocks at the earth's surface ranges between 2 and 3, the substance of the earth's interior at a depth ranging from 1,500 to 3,000 kilometres (approximately 1,000 to 2,000 miles) has a constant specific gravity of 8·8. It is, therefore, as dense as steel, and as elastic as steel. At present, we know nothing more about its properties than this.

Spitzbergen belongs to the Eurasian continental lamella, being separated only by shallow seas from Franz Josef Land, Norway, and Russia.

The geology of the archipelago has been studied by a number of famous investigators, although research here is not easy, since so much of the surface is hidden by perennial ice and snow. According to the usual classification of the geological strata in a presumed temporal succession (a classification based upon palaeontology and upon the observed characteristics of the rocks), from the extreme north-west to Cross Bay the rock is primary and azoic.[1] Southward

[1] Recent researches by Professor Hoel in connection with the Norwegian expeditions have shown that the Hecla-Hook rocks of this region are interspersed with granite.

of Cross Bay, the rocks have the peculiar characteristics of what is known as the Hecla-Hook formation. This disintegrates after the same fashion as the younger rocks, but contains no fossils. The whole of the east and south of Spitzbergen, so far as hitherto explored and geologically studied, consists of younger rocks—devonian, carboniferous, jurassic-cretaceous, and tertiary—superimposed in singularly horizontal strata.

Fjord Formation.—Broadly speaking, Spitzbergen is a tableland, in which (as just mentioned) the strata are markedly horizontal. It is much intersected by fjords, being thus broken up into smaller tablelands, from which the snow and ice find a ready issue, producing erosion in their flow. Some of the fjords, the shallower ones, may have been scooped out by glacial erosion, but no such assumption will explain the origin of the main fjords. For instance, it will not explain the origin of Van Mayen Bay, where the cliffs of the bay and those of Axel Island, which almost blocks its mouth, consist of the same primary rock. Again, if Ice Fjord had ever been completely filled with a glacier, the entrance, which is narrow and shallow, would certainly have been more effectually excavated. There is better reason to suppose that the formation of the Spitzbergen fjords, like that of the fjords

of Norway and Greenland, must be connected in some way with the disappearance of the ice-sheet which once covered the whole country, and with the emergence of the rocks. If we strike a piece of pitch or sealing-wax with a hammer we break it into fragments. But if we place it with one end projecting over the end of a table, subjected merely for a considerable time to the gentle force of gravitation, the projecting end gradually bends downwards. Although these substances are brittle when exposed to a sudden disruptive force, they are plastic when the force acting on them is gentle and persistent. The stony crust of the earth behaves in similar fashion. Folding of the strata bears witness to the action of comparatively gentle and long-continued force ; a fault indicates that there has been a brief and vigorous horizontal pressure.

On grounds of probability we may assume that quite as common as the horizontal thrusts which tear the strata in sunder, must have been the kinds of sustained pressure which lead to plication. We may infer, therefore, that, when the superimposed ice-sheet disappeared and the subjacent rock emerged, at the level of the sea-floor there must have occurred a widening of the plastic foundation, with a resulting laceration of the strata, either at the surface of the earth, or near the surface so that the surface material sank into the fissure. The photographs show clearly,

if we ignore the most notable fracture-lines of earlier date, that Spitzbergen was during its later geological periods not plicated by persistent pressure, but abundantly fissured by potent tensile stresses in a tableland subjected to erosion.

At the edges of the tables where the strata have remained horizontal, there has been extensive lateral pressure giving rise to dislocations, and to marked obliquity of the strata. A further indication of the working of such lateral pressure is to be found in the evidences of volcanic action in the comparatively recent volcanic areas of Wood Bay and Wyde Bay. In Wood Bay, Hoel discovered an extinct volcano, in whose neighbourhood warm springs have long been known to exist. In 1913, when I made a snow-shoe journey to Wyde Bay in order to bring help to the survivors of the Schröder-Stranz expedition, I found on the western shore of Wyde Bay to the south of Graa Hook and above West Fjord, flowing streams with clouds of steam rising from the waters. This was when the air temperature was −30° C. (22° below zero Fahrenheit).

The dendrolites in the more recent geological strata of Spitzbergen prove that the archipelago has experienced extensive changes of climate. I once showed a seal-hunter some of these dendrolites, and told him they bore witness to the fact that ages before there had been great forests in the archipelago. But I did not succeed

in shaking his incredulity, for his comment was that doubtless in those days the whales had wandered through the forests and over the mountain tops !

History.—Spitzbergen has no indigenous population.

As in the case of so many other discoveries, that of Spitzbergen was due to erroneous geographical suppositions. The archipelago was found by navigators who were hoping to sail through the polar seas by a "North-East Passage," and thus to establish a short trade route to the East Indies which would save the need of making the long journey round the Cape of Good Hope. This was in 1596. It was not until nearly three hundred years later that the first voyage round the northern coast of Asia was made, the voyage of Nordenskiöld, who set out from Karlskrona on June 22, 1878, and, after wintering in the ice near Bering Strait, successfully completed his voyage the following year. Previous explorers, many of whom had freighted their ships with trade goods for the Indies, were all baffled by the ice-pack. Their discoveries in Spitzbergen and Nova Zembla were not fully esteemed until a later day.

Whale-Fishery.—These earlier voyagers had also discovered in the seas round Spitzbergen the

home of the Greenland whale, the greatest of extant mammals. The whale-fishery of Spitzbergen began soon after 1600, being first practised by Biscayan whalers, but soon passing into the hands of the English and the Dutch. The trade reached its climax towards 1740, to decline rapidly thereafter owing to the reckless slaughter of the great sea-beasts. For many years in succession, hundreds upon hundreds of whaling ships had set sail for Spitzbergen. The inevitable quarrels between the Dutch and the English whalers led to detailed and fruitless diplomatic "conversations." Ultimately the disputants put their trust in force. The whaling fleets sailed out and returned in squadrons convoyed by warships. Although the whalers had come to some sort of agreement among themselves as to the respective use of the bays and harbours, mutual plunderings and armed conflicts were unavoidable from time to time. The admirals in charge of the convoys, eager for fame, were doubtless inclined, in their official reports, to magnify the importance of these bickerings. But the frays were serious enough, for the whaling ships themselves soon began to carry heavy guns and munitions of war.

Still, though graves abound on the Spitzbergen coast, these bear witness, not so much to the fights among the whalers, as to the intrinsic dangers of their enterprise in the waters of

the northern archipelago. Scurvy, that deadly disease, was rife on the vessels. The illness has always wrought havoc among those who do not get a sufficiency of fresh food. Sailors who deliberately wintered in the north, and whalemen who were involuntarily detained by the ice, of course suffered with exceptional severity. But the courage of the whalemen was amazing. Entirely dependent upon wind power, and often in ships that were poor sailers, they made their way into Hinlopen Strait and round the northern coast of North East Land. Whole squadrons of them would lie in Mussel Bay and in Treurenberg (Trauerberg) Bay, though both of these bays were always threatened with invasion by the ice. Here, when France was at war with Holland, there was a conflict between French privateers and Dutch whalers, as a result of which the Dutch whaling fleet lost seven ships. Here, too, as recently as 1912, a whaling ship with a modern motor equipment perished in the ice. This was the vessel of the Schröder-Stranz expedition, and out of the fifteen members only seven escaped.

The port chiefly used by the Dutch, often in collaboration with German whaling ships, was Smeerenburg Bay (known also as Fat Bay). Here a small port was built, and here, too, when the whalers had more whale-oil than they could carry home, the surplus oil was stored. An attempt was made on one occasion to leave a

guard there for the winter, and the whole garrison of seven men died of scurvy. The last Norwegian whaling station was at Green Harbour. It was abandoned in 1912 because the whale-fishery had ceased to pay.

When, towards the beginning of the twentieth century, sportsmen and tourists began to visit Spitzbergen in considerable numbers, and when, in the kindness of their hearts, or in search of mementos, these visitors began to rifle the graves, the Dutch government sent a warship to Spitzbergen and the remains were all exhumed and reinterred in a general tomb. This rung down the curtain upon the last act in the drama of the Spitzbergen whale-fishery, and closed an epoch of free and fearless seamanship.

Seal-Fishery.—The seal-fishery which has taken the place of the whale-fishery is in Norwegian hands. But sealing likewise is on the down grade, and for the same reason. The seals are in danger of extermination. Although smaller and smaller vessels are used year by year, they often fail to repay expenses. Still, the seal-fishery, too, has developed seamen of whom any nation could be proud.

Fishers and Hunters.—Towards 1800, a sort of permanent settlement in Spitzbergen began. Norwegian and Russian hunters and fishermen,

combining in small groups by twos, threes, and fours, acting independently or paid by an employer, would winter in the archipelago to hunt arctic foxes, seals, reindeer, and polar bears. Coming over with the summer whaling fleet, they would go home the following summer, returning to Spitzbergen often enough the very same autumn. They were housed in miserable huts of planking, and relied on hunting for their food. A trifling accident, under these conditions, was likely enough to entail disaster. Not one of the numerous bays of Spitzbergen but has been the scene of some such tragedy. Sometimes when illness, or hunger through unsuccessful hunting, had claimed a first victim, the survivor or survivors would escape to the nearest neighbouring settlement. Thus a hunter whose sole companion had died made his way southward from the mouth of Wyde Bay across the unknown mountains to a settlement in Advent Bay. A crew whose vessel had been caught in the ice-pack off the north coast, took to the ship's dinghy, and in this rowed along the northern and western coasts as far as Ice Fjord, whence the men were taken home in safety. Sometimes, however, a passing vessel will send a boat ashore to one of these settlements, and will find the settlers dead inside their snowed-up hut. If no written record has been left, the would-be rescuers can only guess at the tragedy which has been covered up by

the pall of snows and is wrapped in the grim silence of death.

Nevertheless, and despite all the discomforts and dangers of this life in the far north, when the hunters and fishers return to their homeland, with its electric light, cinemas, taxes, taverns, policemen, law and order, and all the other privileges and amenities of civilisation, they are apt to find that the life of the everyday world is uncongenial. The call of the wild often proves irresistible. Back they must go to snow and peril and solitude, to storm and darkness and scanty fare, because the desert of snow and ice has something to offer them which they prize more than all the comforts and allurements of civilisation—liberty. They have been uprooted from their native land. In the long polar night, their thoughts may often have turned fondly homeward, and yet they cannot live at peace under the old orderly conditions. Inevitably they yield once more to the pull of the magnetic north.

The financing of these expeditions by one who lives at home at ease is a risky business for more reasons than those already mentioned. Unless the entrepreneur appears on the northland scene directly the ice breaks, he is not unlikely to receive from his hunters nothing more than a few odd skins and complaints of a bad season.

Spitzbergen is No Man's Land. Crime and

1. Tromsö, seen from the north-east, at a height of seven hundred metres.
In the left background the beginning of Bals Fjord.

2. View southward from the Tromsdalstind (1238 m).
In the middle is Ram Fjord; in the background, Bals Fjord.
Taken in June 1923.

3. Panorama from the Tromsdalstind looking towards the north-west.
In the centre foreground, Tromsdalen; then Tromsö; in the middle distance, Sand Sound.

4. The Anker Company's hut fifty metres above the Wireless Station.
In the Bay to the left is the Junkers Airplane Station.

punishment, in the legal sense of the terms, are unknown. Anarchy prevails here, as in northern and eastern Greenland. A good many Scandinavian publicists have been outraged by this fact, and they quarrel among themselves as to whether Spitzbergen ought to be a Danish or a Norwegian colony. Their ink boils over when they write on the topic, and the controversialists on each side complain of the lack of colonising zeal displayed by the government in whichever country happens to be their own.[1]

Coal.—Under normal conditions, and in other climes, the settlement of a new country occurs in three stages. First of all, the immigrants live by the chase. Then, when wild life is growing scarce or when the population is becoming too thick for this primitive means of livelihood to suffice, hunger drives the settlers to agriculture. When that source of provender likewise begins to prove inadequate, not from primary insufficiency so much as because the land has all passed into private possession and because the food raised on it is the property of the landowners, that portion of the population which is not engaged in agriculture bestirs itself to rifle the earth's treasure houses, to mine coal and metallic ores.

[1] Since 1924 the archipelago has been under Norwegian suzerainty.

In Spitzbergen, owing to the harshness of the climate, agriculture is impossible, and the second stage of colonisation finds no place. After hunting and fishing, mining is the only source of livelihood. The first attempts in this direction were made upon the coal-measures. These extend almost horizontally, and with very few faults, in the tertiary, cretaceous and carboniferous strata, from King's Bay to Bell Sound. At the outset of the present century, after several minor attempts had been made, an American company set to work in Advent Bay (in Ice Fjord), intending to conduct the exploitation in the grand style. During the war, this mine became Norwegian property. Other mines have been opened eastward of Coal Bay in Ice Fjord at the entrance to Green Harbour, in Braganza Bay, and on the south-western shore of King's Bay. Most of the miners are Norwegians, and about a thousand of them now winter in Spitzbergen. There was considerable friction at first between the miners and the original American entrepreneurs. For the protection of the workers, the Norwegian government has now established a wireless station in Green Harbour. This is in constant touch with Ingö in northern Norway, and can keep the homeland informed regarding the needs of the colonists. By the terms of the latest treaties, any legal disputes must be settled in Tromsö in accordance with Norwegian laws.

The Green Harbour mine belongs to a Dutch company and the Braganza Bay mine to a Swedish company. The other mines are Norwegian.

We are told by the mine-owners that the Spitzbergen mines offer many advantages. Since the ground is frozen to a depth of about 400 metres (1,300 feet), the pits are free from two of the chief dangers of coal-mining in other parts of the world—inundation and firedamp. The miners are not troubled by heat during their underground labours, and must keep vigorously at work if they would escape being frozen. The pit-props are everlasting, for the climate does not suit the micro-organisms which cause wood to rot. Civilised man seeks out this inhospitable land because he must work to live. Microbes, being uncivilised, are under no such constraint. Those of them which, from a sense of companionship, have accompanied man into the northern wilds, find that at temperatures ranging forty degrees below zero the claims of death are more urgent than the ties of friendship, and they leave the perpetuation of the species to their southern colleagues. Even the pathogenic micro-organisms are hard put to it to keep going.

Moreover, during the long winter night, the miners are not troubled by having to say farewell to the daylight when they go to work underground. It is no darker in the pit than under the open sky. And if, among the miners, there

be those who repudiate the sublime teaching of civilisation that man cannot live by bread alone but needs work as well, if there be those who cling to the pagan idea that bread alone suffices, let them try to follow their fancy after the last ship has sailed for home in the autumn. They will soon realise that work in the pits furnishes their only source of warmth and food supply.

Until recently the coal, when mined, has been simply heaped up on the quay to await shipment in the summer. There it freezes into huge masses, and has to be thawed out or broken up once more when the time comes for lading. Attempts are now being made, therefore, to store the coal under shelter throughout the winter and spring.

Transport is the main difficulty, for the harbours are open for no more than a few weeks in the year. Even during these weeks, the seas are full of drift ice, and the ships must be protected by a so-called "ice-skin," a wooden cuirass, which saves the essential part of the hull from being staved in by the ice. But the presence of this ice-skin makes the vessel uneconomical to navigate during other months and in other waters.

If ordinary colliers are used for transport (and that is now done in the case of all the Spitzbergen mines), they must often steam by circuitous routes to avoid the drift ice, and this makes it impossible to keep to a regular time schedule.

The general disorder of the contemporary world economy has proved advantageous to the Spitzbergen coalmines. Owing to the territorial arrangements made by the Treaty of Versailles, in conjunction with the lien on the production of those mines that remain in German hands, the Anglo-French league and its dependents control the product of all the European coal-mines. The States that are still independent, and desire to remain so, must turn to other sources of supply. The British post-war tax upon exported coal has deprived the Norwegians of all the advantages they had derived from the economic support of their British neighbours during the war. It is unquestionably a sound fiscal policy for Norway, which has in any case to pay more for its coal, to pay this extra in the form of a subsidy to the Norwegian mines in Spitzbergen, rather than in the form of a tax upon the British export (for, if the tax be paid, it is of course paid by the foreign consumer). When happier days come, the Spitzbergen mines can still be made to pay, owing to the progressive exhaustion of the European coal-measures. Such, at any rate, is the sanguine outlook. The question will be reconsidered in a moment.

Ores and Marble.—Metal mining has not yet been undertaken in Spitzbergen. In King's Bay, however, an attempt has been made to quarry

marble. The enterprise came to nothing because the marble broke up along the veins as soon as it was transported to temperate regions.

Owing to the severity of the climate, and owing to the difficulty of transport, it is much harder to make mining and quarrying pay in Spitzbergen than in other counties. Probably, therefore, after a very superficial exploitation of the mineral resources of the archipelago, the land will be left once more to its primeval solitude. Trodden only by a few hunters and fishermen, who are content with small earnings and hard fare, it will remain a last refuge of anarchy, remote from civilisation and the covetousness of civilised human beings. I must repeat, however, that many Norwegian experts take a more favourable view of Spitzbergen's possibilities. Coalmining at any rate, they hold, has a great future in this part of the world.

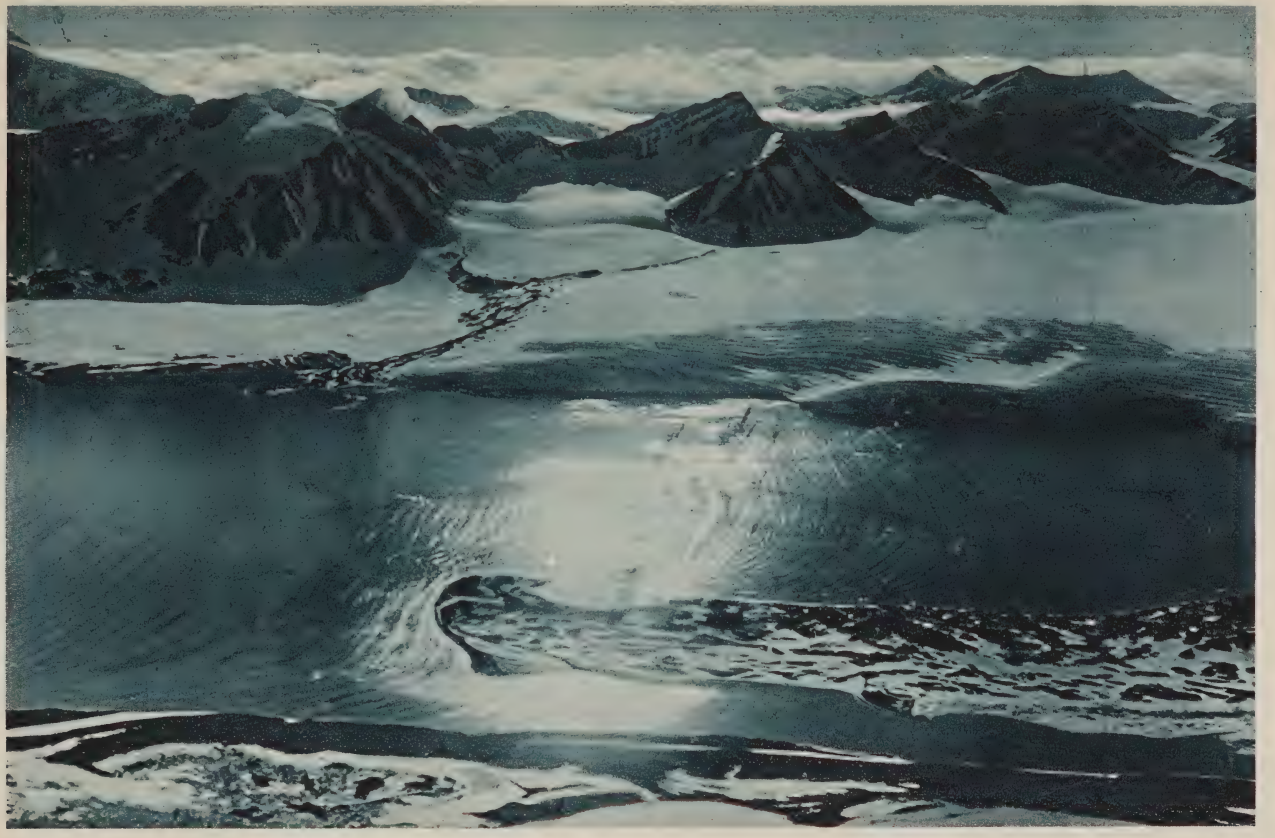
AIMS OF AIRPLANE PHOTOGRAPHY

An expedition to a new country is groping in the dark. The explorers will make many false steps, because there are no trodden paths. They cannot plan out their course judiciously, because the materials for a wise judgment are lacking. They wander among mountain peaks without the faintest notion of what may lie on the other side of the ranges. Should they climb one of the mountains in the hope of securing an extensive view, they will as likely as not find themselves wrapped in cloud, or perhaps surrounded by higher summits. For these reasons, airplane photography should always be the first stage of exploration. The primary aim must be to secure bird's-eye views of the region to be explored. The airplane survey is not itself exploration. The area is too vast; the impressions are too multifarious; the time is too short. A general impression, even, can be better secured by a subsequent study of the photographs than during the actual flight. The photographs do not hustle past, but remain to be looked at as long as we

please. During the flight, the observer's attention concentrates for a moment, now upon this point and now upon that, and often enough a leisurely examination of the photographs will show that these points are of very little importance. Furthermore, owing to the rapidity with which the impressions succeed one another during the flight, the memory is apt to be confused, and we shall be unable to recall accurately the temporal and spatial succession. The photographer himself has very little time for making observations. He will be fully occupied with noting the number, place, and time of the pictures, and with recording the altitude from which the photographs are taken, for if these details are not jotted down upon the instant it will hardly be possible to recall them when the flight is over. The photographer's business is to work hard and to work swiftly, not to see. But when good bird's-eye views have been secured, the study of these will enable the explorers to plan out their terrestrial expedition.

The second aim of airplane photography is to provide the materials for accurate map-drawing. As to method, this depends upon the degree of accuracy demanded by the circumstances of the case, and by the amount of the extant knowledge of the country. If the horizon is shown upon the picture, or upon a closely related picture, and if the height from which the view

5. Wireless Station (formerly Whåling Station) of Green Harbour.



6. Ymer Harbour with the Esmark Glacier and the Vermland Range, seen from the east, at a height of eight hundred metres.

was taken and the focal distance of the apparatus are known, a single photograph will enable us to determine the coast-line and the course of the rivers. In the plains, it will supply us with all sorts of details. In the mountains, if it be possible to estimate their approximate height, it will disclose to us the shapes of the peaks.

Another method, which is extremely simple, but correspondingly inaccurate, is to take almost vertical views from a very great height and with a short focal distance, combining the study of these with the study of oblique pictures. Both this method and the one previously mentioned presupposes that from time to time points in the picture can be correlated with points whose trigonometrical or astronomical relationships are fully known; also that the photographer has secured a series of pictures adequately covering the area under survey.

A careful pictorial survey must always be the main object of such an expedition. It is, however, natural that, in view of the technical difficulties of flight, there should be a tendency to concentrate upon these matters, and to regard scientific requisites as unessential ballast. It is by no means easy to hold the scales even between these two claims. Assuming photographic survey to be the primary object, photographs can only be taken when airplane, pilot, and mechanic are on the spot. The scientific equipment must

therefore be as simple as possible, and unduly elaborate methods must be eschewed.

I have referred hitherto only to photographs of the land areas. In addition, however, it must be remembered that airplane photography affords unrivalled opportunities for the study of the distribution and the peculiarities of the oceanic ice.

WHAT CAN BE LEARNED FROM THE PHOTOGRAPHS

Among the numerous views, about twenty included a sufficiently extensive prospect to give a real insight into the features of the country. The other pictures, though of less value from the geographer's outlook, still convey much interesting information. About thirty of them, for instance, tell us quite as much about the geological features of the country as can be learned from mountain climbing, and to secure these pictures required minutes where mountain climbing would have occupied as many days. But from the surveyor's outlook these views are of less value, seeing that the point from which the photographs were taken has to be inferred from a study of the pictures.

Cartography.—In the cartography of a mountainous country there are three different ways of indicating the third dimension, three ways of showing altitude. These three ways are : contour lines, hatching, and shading. (There

may, of course, be a combination of the use of contour lines and shading, as when the gradations of height are indicated by the use of different colours, ranging usually from light green to dark brown.) Our pictures show that in the cartography of Spitzbergen we can best imitate nature by a joint use of all three methods. In the regions of marked erosion (Fig. 6), we see a sort of natural hatching; in the flatter forelands (Fig. 41), and in the old coast-lines and the tundras, plastic contour lines are visible; while the snow-clad peaks are, in nature's way, set forth by shading.

Glacier Formation.—Our pictures show clearly that glacier formation is the outcome (apart from altitude) of two factors, namely: the local strength of the wind; and the hardness of the rock. Heaping up of the snows is the essential preliminary to the formation of glaciers; and where the prevailing winds are so strong that the snows cannot lie and snowdrifts cannot form, there are no glaciers. Thus the whole of the west coast, being exposed to the strong west winds, is poor in glaciers. On the north-west coast (Fowl Bay), there are many glaciers among the granite hills; but in the same region the islands, likewise of granite, have no glaciers. The smooth tertiary plateau contains few glaciers, although this region is less windy. Look, for

instance, at the pictures of Lomme Bay (Figs. 38, 39, and 40). The difference, as regards glacier formation, between a resistant stone and a stone that disintegrates readily, is well shown by a comparison of the picture of Fowl Bay (granite, Figs. 23 and 24) with that of Hecla Hook. In the former case the frost has certainly to some extent enlarged the natural fissures in the rock, but the downward flow of water, snow, and detritus has not cut any deep furrows. There is no talus forming a shore along which it is possible to walk, for the rock runs right down into the sea. Snow and ice are piled up upon every little ledge of rock. Entirely different is the western shore of King's Bay. Here most of the glaciers come to a dead end upon the soft stone. The mountain masses are surrounded by wide forelands. In this locality, the conditions of wind, snowfall, and altitude resemble those of the extreme north-west, with similar results as regards the comparative absence of glacier formation.

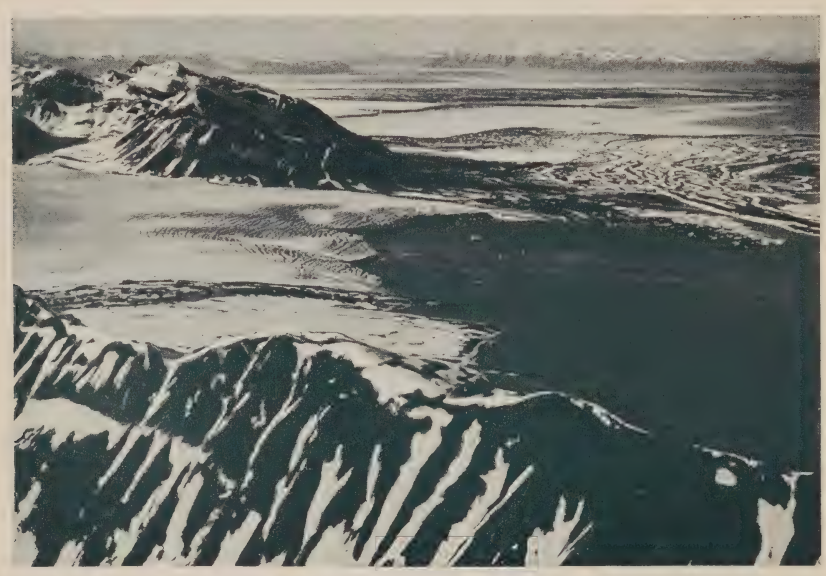
In the European glaciers, the dwindling of the ice goes on from both above and below. The rivulets formed by the thawing of the ice run, not only on the surface, but also beneath the river of ice, at whose base the warmth of the ground is continually gnawing. In Spitzbergen, on the other hand, the bed in which the glacier lies is frozen hard from year's end to year's end.

During the summer thaw, runnels and pools form on the upper surface, as we see in Fig. 42 showing the Eidem Glacier, but the depths of the ice-stream are quite unaffected. It is owing to this surface action that the appearance of the glacier depends so much upon the nature of its rocky channel. When the cliffs that overhang the glacier are of a stone that readily disintegrates, we see, not merely that the rock sheds its own snowy covering comparatively early in the summer (because the mixture of stony debris and snow absorbs the heat of the sun more rapidly than does a pure snow stratum), so that there is less snow to feed the glacier, but also that the rocky detritus falls upon the surface of the glacier, and that this promotes thawing and wastage of the ice as soon as the sun shines. The disinclination of the younger and more friable rocks to wear a snowy coat is manifest in many of the Spitzbergen valleys. We see it, for instance, in the Sassen Valley and in Wood Bay. The pictures of Lomme Bay (Figs. 38, 39, and 40) show it well. So do those of the Culm Quarter (Fig. 12), the Brögger Peninsula (Fig. 37), and the Reindeer Peninsula (Fig. 41). It is thanks to the freeing of the land from snow and ice in certain parts that the reindeer indigenous to Spitzbergen are able to find nourishment even in winter.

7. The Members of the Expedition in Front of the Junkers Airplane near the Wireless Station. From left to right: A. Neumann, H. H. Hammer, F. Duhs, W. Mittelholzer. Above: W. Löwe, Holbein, Wegener.

8. Dutch Coalmines in Green Harbour, seen from the west, at a height of seven hundred metres. The s. s. "Ameland" is lying at the pier. To the left, the "Farm" is under steam. In winter the pressure of ice in the fjord often damages the pier.

9. Mount Protector and the Alkhorn at the entrance to Ice Fjord, seen from a height of eight hundred metres. In the right background, Safe Bay and Ymer Bay with the Esmark Glacier and the Erdmann Tundra. In the centre background, the peaks of the Trollheim Plateau.



10. The Esmark Glacier, which is about five kilometres in width, seen from the south, at a height of eight hundred metres. At the foot of the Dalsland Range (left middle distance) we see the Erdmann Tundra (which has an area of about forty square kilometres). Farther back, the Nansen Glacier, the Bore Glacier and the Boheman Tundra. Above Ice Fjord, in the right background, the Stockholm Quarter.

Denudation.—When we look at Nunataks on the Firn Plateau (Figs. 25 and 26), we cannot help wondering whether the obvious denudation is due to glacial action or to the summer thaws. We ask ourselves whether, when once the formation of a firm continuous ice-sheet has been achieved (as in North East Land), there will be much further denudation effected by the glaciers and the ice-sheet. It would almost seem as if there was a design in the carrying down of all this moraine debris by the glacier, the design to wear away Nunataks, which now, by its projection, disturbs the symmetry of the ideal ice-field! Will not comparative peace reign when the head of Nunataks no longer shows above the ice—unless the ice-field be broken up by new pressure or fissuring? We can perhaps best picture the process of denudation as follows. The rocks are split by the alternation of frost and thaw, and the fragments are washed away by water, so that in time even the finest plateau is scooped out into a skeleton. If the process is far enough advanced, the levelling ice-field gradually swallows up the dwindling remnants of the peaks, to cover these at length, as turf grows over a gradually subsiding mound of earth—until at long last there is nothing left but a gentle undulation in the ice-field to mark the site of a once proud mountain top.

Advantages of Airplane Views.—The admirers of the antique, and of all antiquated methods, have good reason for their complaint that for many kinds of scientific investigation the airplane is unsuitable. It certainly cannot help us much if we are botanists; or if we wish to study the habits of foxes in their burrows; or if we are anxious to collect fossils. But our ideas concerning the structure of mountains are not based solely or mainly upon palaeontology, but upon the general study of their shapes. Again, we have not hitherto had any cartographical representations of pack ice and drift ice. In such matters as these, airplane photography can furnish us with information of incomparable value. By the use of the airplane we are enabled to obtain views in which we escape various optical illusions that are inseparable from observation upon the ground level.

In ordinary circumstances man, with his low stature, is two-dimensional rather than three-dimensional. He is like a bacterium upon the surface of a paper globe; like a mathematical point in a mathematical plane. Even when he climbs to the top of a high mountain, he is still two-dimensional, still bound to the surface of things. Imaginatively, logically, or emotionally, he constructs three-dimensional space for himself; but such space does not for him become a matter of perception as well as imagination

until material wings lift him above the surface on which he ordinarily lives, moves, and has his being, so that at length to his very sensorium the door of three-dimensional space has been opened.

If any one has a taste for climbing mountains and the use of the geologist's hammer, or a taste for paddling in slush on an ice-pack or a tundra, I will not say him nay ; but for his part let him not deny me the new and rare pleasure of my bird's-eye views.

PHOTOGRAPHY FROM AIRPLANE

By PROFESSOR A. MIETHE

PHOTOGRAPHY FROM AIRPLANE

PHOTOGRAPHING from an airplane requires arrangements very different from those requisite for the taking of ordinary photographs. When we photograph an ordinary view from the ground level we usually have to do with objects that display a rich gradation of shades and colours. Between the brightness of objects in the foreground and the brightness of the sky, there is often so marked a difference that we may hardly be able to deal with so extensive a divergence. The photographer often finds it difficult to expose the plate long enough to bring out the details in the darker parts of the picture, without overexposing the lighter parts to such an extent that here all the gradations of shade are lost.

In photography from airplane, the converse difficulty arises. Inasmuch as the objects to be shown in the photograph are all at a great distance, being, in photographic terminology, all "at the same distance," the scale of tone and colour is a very short one. Owing to the remoteness of even the nearest objects, and owing to the opacity of the air (which, as is well known,

is far from being a perfectly translucent medium), the differences between light and shade are toned down. In technical phraseology, the differences of luminosity are minimised. The obscuration due to the opacity of the atmosphere causes a diffuse reflexion of light, so long as the comparatively non-translucent strata attain a certain thickness. In normal circumstances, the less transparent strata are the lower ones, those that form the part of the atmosphere in close contact with the earth. The amount of obscuration, will, therefore, be proportional to the horizontality of the photographic apparatus in the airplane, for the light has to traverse a much greater extent of the comparatively opaque stratum when an almost horizontal than when an almost vertical photograph is being taken.

When the obscuring stratum is fairly thin (and this is the case on clear days when a photograph is being taken from a considerable altitude), it has a refractive effect. This refractive influence is most marked upon the light-rays of shorter wave-length, with the result that in a clear atmosphere the distance is enveloped in a blue haze. Thereby all the shaded portions of the view are made to appear brighter than they otherwise would.

If we study the actual view from an airplane a very simple experiment will show how notable this brightening effect is. If we compare the

brightness of a sheet of white paper held in the shade with the deepest shadows in the landscape over which we are flying, we find that at a distance of a few kilometres even a black wall of rock has a brighter shade-tone than that of the white paper.

As far as airplane photography is concerned, there is no remedy for this atmospheric effect. When taking our pictures we must always anticipate that there will be a comparatively small luminosity gradation in the more distant parts of the prospect. The light and the dark in this region of the picture will tend towards a neutral shade. But when the shortening of the shade-scale is mainly due to the obscuring effect of the comparatively translucent upper strata of the atmosphere (and this is nearly always the case when we are photographing from a great altitude), we can remedy the trouble to some extent by the use of a yellow disk or colour screen. This is a plate of glass having a pure yellow colour, interposed quite close to the objective, and it acts by absorbing the blue rays of light. Any one who takes the trouble to put on a pair of yellow-tinted spectacles will at once realise, as soon as his attention is directed to the matter, that the shade-scale of distant objects is thereby lengthened. The effect is still more marked in the case of the photographic plate, for this, even when used as a colour-sensitive

plate, is far more sensitive to blue than to yellow light.

The foregoing considerations show that a yellow disk will only have a perceptible or satisfactory effect when the atmospheric light is blue, that is to say when the shaded parts of the view are made lighter by the absorption of blue rays. When, on the other hand, there is a universal haze, so that the brightening of the shadows depends upon rays of all wave-lengths, the yellow disk has no influence.

All the rays of the spectrum, except the blue-violet, traverse a yellow disk. The red, the yellow, and the green rays pass through it freely. If, therefore, in conjunction with a yellow disk, we use a so-called panchromatic plate, one sensitive to all the rays named, the tone-scale of the object will depend upon the luminosity differences only, and not upon the colour differences. With such a photographic equipment, as compared with that in which an ordinary colour-sensitive plate is used, the contrast effect in the object will be reduced rather than intensified. A considerable advantage can likewise be secured by the use of a red-sensitive plate in conjunction with a disk that more or less effectively filters out the red rays, for it is at least possible that this will intensify the contrasts. Moreover, there are additional advantages, which will be considered shortly.

For airplane photography in the arctic regions, the use of a yellow disk whereby blue and violet rays are completely excluded will be the best way on all occasions, for here the aim of the photographer is to display the tone gradations in snow-covered surfaces, and the contrast between such surfaces and dark rocks. In such views there is a considerable bluish component in all the light radiations, and for this reason the yellow disk will intensify the contrasts.

While the use of a colour filter in conjunction with a colour-sensitive plate thus obviously affords the best means for intensifying the contrasts in the negative, we shall, of course, get still better results when we supplement the optical measures by photochemical measures which will reinforce the effect. When our pictures are to subserve the purposes of the cartographer, we are not so much concerned with their artistic beauty as with their perfect intelligibility. For this reason it is of the utmost importance that the contrasts shall be intensified as much as possible.

The photochemical means whereby the contrasts in a photograph can be intensified are of two kinds. It is possible to accentuate the steepness of the gradations in the plate; and it is also possible, given a particular gradation curve in the plate, to secure as hard a negative as possible by suitable illumination, and above all by the process of developing.

The ordinary colour-sensitive plate almost always works more effectively towards this end than the mother emulsion, which is non-sensitive to colour. The iodofluorescins will generally make the gradation curve somewhat steeper. There is no reason, when preparing the emulsion, why we should not do anything we can which will make the curve steeper. During the war, with a special eye to this effect, plates were prepared for airplane photography designed to secure an increased gradational hardness. But we must be careful not to go too far in that direction. The steeper the gradation curve of a plate, the narrower will be the range of possible exposure, and the more accurate must be the "dosage" of the exposure if a good negative is to be obtained. Very high demands are thus made upon the technical skill of the airplane photographer. He must have had ample experience in the estimation of the intensity of the illumination at the moment of photographing. Every one who knows anything about photography is aware that this question of the right exposure is a very delicate one. The various exposure meters that are recommended for guidance to a decision upon this point can never replace the photographer's practical experience. Nay more, there would seem in many cases to be a sort of inborn talent for judging exposures. Besides, in airplane work there is scant opportunity for using exposure meters.

11. The Mittag-Leffler Glacier, seen from the north, at a height of seventeen hundred metres.
In the distance, Ice Fjord.

12. The Horbye Glacier (the Culm Quarter), seen from the east, at a height of sixteen hundred metres. Note the fine gorges.

If the estimation of correct exposure is already difficult enough in the case of a plate with the normal steepness of gradation, it is enormously more difficult when such very steeply graduated plates are used. In this connexion I may refer to the Lumière autochrome process. For reasons which are not relevant to the present discussion, the Lumière plate must have an exceptionally steeply graded emulsion, and any one who has worked with such a plate must know how difficult it is to manage. An ordinary colour-sensitive plate has so great a range of exposure that it may be hardly possible to distinguish prints made from two different negatives when one has been exposed five times as long as the other. But if a Lumière plate be exposed for only half as long again as the optimum time of exposure, the result will be most unsatisfactory. For airplane photography, therefore, especially in the arctic regions, we must be careful not to overdo the steepness of gradation in the plates. If the photographer is highly skilled, and has had ample experience in estimating correct exposures, he may get good results even when the steepness of gradation has been overdone. Sometimes, almost by chance it would seem, the results may be admirable. But in ordinary circumstances, and when the aim is to get fair average results with as few failures as possible, the photographer will do well to renounce the use of this two-edged weapon. It

only secured fame during the recent campaigns because those in high authority never learned how small a ratio the successes bore to the failures.

The second way of intensifying the gradation is to do it during the development of the photograph. Even upon a plate that takes soft pictures it is possible, provided the exposure has been right, to develop a negative showing good contrasts. The means requisite for producing this effect are as follows. As is well known, in the initial stages of the developing process the developer brings out the picture by a gradual penetration of the sensitised stratum. While this process of penetration is going on, the reduction of the silver bromide is beginning, and if the developer has such a composition that most of the reducing substance is exhausted before the change has penetrated deeper than the most superficial layers, a very faint picture results. In proportion to the extent to which, in the course of the prolonged process of development, the developer is changed thanks to diffusion into the deeper layers, the developmental process makes its way inwards, and the development of the superficial strata is intensified. It is obvious, therefore, that, when the developer is poor in reducing substance (especially when the exposure has been rather long), the superficial strata will be much more adequately developed than the deep-lying strata—although the light-and-shade

gradations will really be more accentuated in the deeper but comparatively undeveloped parts of the picture. It will often be necessary to stop the development before the maximum gradation curve proper to the plate has been brought out. The final result will be all the less satisfactory in proportion as the exposure to light was intense ; and yet, for obvious reasons, the usual advice is to err on the side of length, rather than on the side of shortness, of exposure.

If we wish to avoid these drawbacks, the remedy is plain. We must make sure that from the outset of the developing process there shall be an abundance of reducing substance to penetrate into the deeper strata, and this will be achieved by using a developer which, while otherwise normal in composition, is richly supplied with reducing substance.

Thus, in defiance of the common (and erroneous) opinion, the developer used in airplane photography should contain large quantities of a fresh and extremely active reducing substance. When developing our pictures, we must not be alarmed by the rather uncanny speed with which the picture begins to show up, or by the speedy darkening of the plate. We must continue the process until the picture is visible from the glass side, not only on the lights, but also in the deep half-tones. A negative developed in this way will often look rather unsatisfactory.

But we shall get good prints from it; and, after all, that is the main point. If we want to beautify the negative, we can always do so by subsequent toning down with ferrocyanide of potassium—though this will not give us a better print.

It matters little what developer is used, so long as there is plenty of it. For airplane photography I can specially recommend ordinary rodinal in a twelvefold dilution, with the addition of one gramme of hydroquinone to five hundred cubic centimetres of the diluted developer.

In airplane photography the optical equipment is of supreme importance. The airplane is in rapid motion forward, and there is even a danger that there may be a twisting movement while the exposure is in progress. The exposure, therefore, must be as short as possible. The briefer the exposure, the better the chance of a sharply defined picture. The illumination of the plate during this brief period must, therefore, be as intense as possible. There are two factors to be considered here, the rapidity of the lens, and the efficiency of the shutter.

As regards the lens, we need one which will give the sharpest possible illumination in conjunction with exceptionally good definition. Owing to the particular way in which lateral distortion is corrected in the best modern lens

combinations, a picture with a universally satisfactory definition will only be secured when the correction is accurately adapted to the shape of the plate. In the case of every anastigmatic objective (and it is only of such objectives that we are now speaking), when the centre of the image is accurately focussed there will be a decline in the sharpness of definition as we pass towards the periphery, and then we shall come to a marginal zone in which sharpness of definition has been regained. By the method of correction, we can regulate the distance of this marginal zone from the centre; but the farther it is from the centre, the more defective will be the definition in the intermediate zone, and the steeper will be the decline in sharpness of definition beyond the neutral zone. In the case of airplane photography, therefore, since extreme sharpness of definition is a great desideratum, we must see to it that the correction of the objective is as well adapted as possible to the chosen form of plate.

Passing now to consider instantaneous shutters, we find that the efficiency of central shutters is usually less than 50 per cent. When the aperture of the lens is a large one, it is difficult, in the case of such shutters, to get sufficiently rapid exposures. Also, the mechanism of these central shutters is so much affected by the temperature that over-exposure or under-exposure is very apt to occur. The Goerz-Anschütz focal plane

shutter, and other slit shutters, are free from these defects, and their efficiency is 100 per cent. When properly constructed, their mechanism is practically unaffected by changes of temperature, and the time of exposure can be very accurately modified, measured, and controlled. The tension is a matter of primary importance. Experienced photographers will generally use the highest possible tension, and will secure the requisite length of exposure by widening the slit as much as may be necessary. This is advantageous in many ways, and especially for photographs that are to be employed mainly for cartographical purposes. We have to remember that the working of the slit shutter is such that the plate is illuminated in successive strips. If the airplane is moving forwards rapidly, there will, therefore, be a tendency to distortion in the picture. The more slowly the slit shutter works, the slower (that is to say) the passage of the strip of light across the plate, the greater the risk of this distortion. We counteract the danger by increasing the tension and widening the slit.

It follows from these considerations that a satisfactory central shutter would be the best kind of shutter, especially for photogrammetric work. Until recently no central shutter meeting rigorous requirements had been constructed. Now, however, the problem has been solved by the construction of moving blade central shutters

and iris shutters which render possible the perfect regulation of the exposure. A shutter of this kind has been designed that will be unaffected in its working by changes of temperature, but it is not yet on the market, and its designers (the Aerogeodetic Maatschappij, a daughter company of the Optische Anstalt C. P. Goerz A. G., Berlin-Friedenau) have no immediate intention of marketing it. For the nonce, then, and until this perfected central shutter is procurable, the Goerz-Anschütz focal plane shutter holds the field for arctic airplane photography.

The objective for airplane photography must have a very high light-strength. A maximal aperture of 1 : 4·5 will be requisite.

Obviously, then, in the construction of a camera for airplane work, all these points have to be carefully considered by an expert, and it will not suffice simply to take any good anastigmatic combination and to build it in to any camera you please.

Still, our optical works are fully equal to the demands made upon them in this respect, as the pictures taken with the Goerz-Dogmar apparatus during the Spitzbergen expedition show very well.

Even more exacting are the demands in the case of an objective for cinema work from airplane. But our expedition secured excellent results in this field likewise.

GEOGRAPHICAL VALUE OF THE PHOTOGRAPHS

By CAPTAIN H. BOYKOW

GEOGRAPHICAL VALUE OF THE PHOTOGRAPHS

THE primary aim of this expedition was to be ready to assist Amundsen in his projected flight from Point Barrow in Alaska across the Pole to Spitzbergen—to bring him aid in the event of his being unable to complete his flight. Its secondary aim was to take cinematic and other photographs of Spitzbergen, partly with an eye to defraying the costs of the expedition. When Amundsen's scheme, in the above-mentioned form and at the date originally planned, was abandoned, the secondary aim became primary. But here a difficulty arose, seeing that the equipment had been essentially designed for the fulfilment of what was at the outset its primary aim. That is why the expedition did not achieve all it might have achieved had it been fitted out solely with a view to securing the greatest possible amount of geographical information by the use of airplane photography.

When the net upshot, the effective value, of

such an expedition is being appraised, three main questions have to be answered.

1. To what extent has science been enriched by the photographs actually secured ?

2. Speaking generally, how far has the expedition, despite its improvised character, furnished valuable results ?

3. What could an expedition fully equipped with the armamentarium rendered possible by modern scientific technique have been able to achieve in similar circumstances ?

First, then, to what extent has science been enriched by the photographs actually secured ?

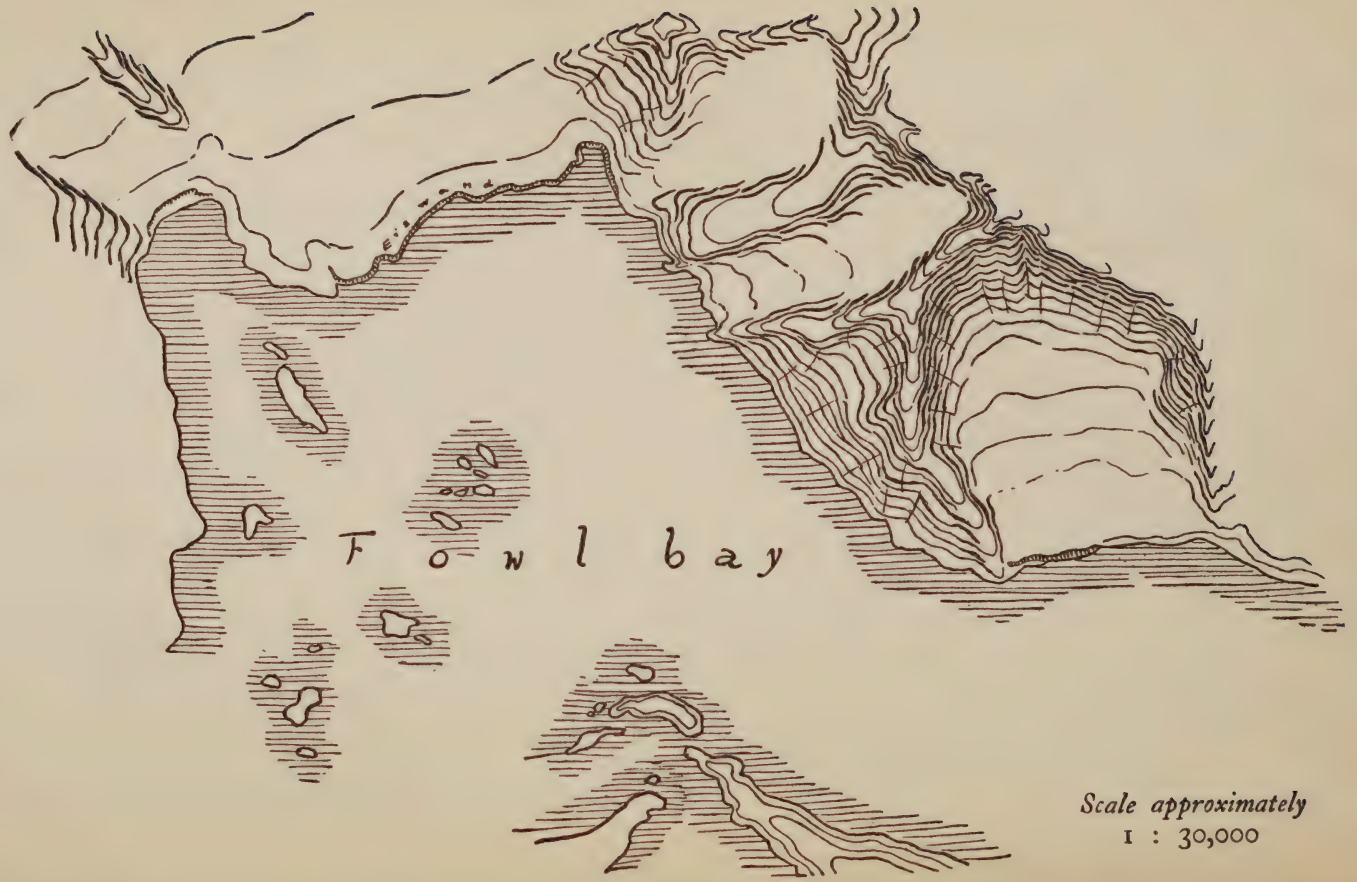
When we bear in mind that the original aim of the expedition was something quite different from airplane photography, that the pressure of events made the preparations unduly hurried, and that under these conditions it was impossible to train the staff adequately for the work of airplane photography, I think it cannot be denied that the achievements were very remarkable. An expedition specially equipped for geographical survey, but lacking the help of an airplane, would not have been able in many months to secure anything like as much information as was secured in a few days with this extemporised equipment. No doubt, had it been possible to make a more extensive use of the actual equipment, still more remarkable results might have been achieved.

But this consideration does not discredit what was, in fact, done; it serves only to emphasise the immense assistance the airplane can render to the geographical explorer in these regions.

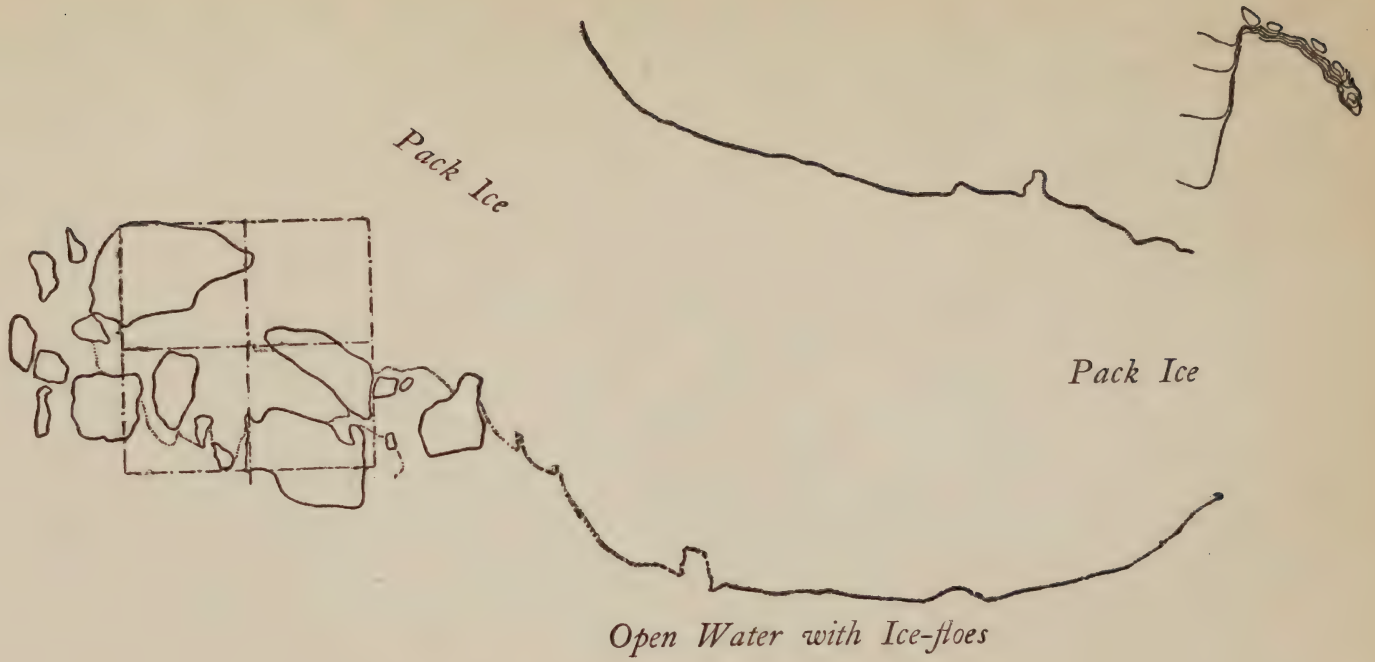
While it is true that most of the photographs taken are not much more than interesting views of the local landscape (though even these might readily be turned to geographical account), nevertheless a number of the pictures facilitate geographical deductions of the first importance, such as would have been unobtainable in so short a time by any other means.

In this booklet there are some specific examples of the use which can be made of such pictures. For instance, the sketch-map of the inner part of Lomme Bay (see end of book) is made by the simple anagraphing of the three views of this bay shown in Figs. 38, 39, and 40. The sketch, of course, has no pretensions to geographical exactitude, for the only accurately known data were the altitude of the 'plane when the photograph was taken (barometrically determined) and the focal distance of the camera. The horizon and other details had to be estimated. Still, this sketch-map is enough to show that a good use can be made of exceedingly simple views.

In the pictures of Fowl Bay, Figs. 23 and 24, we can clearly see the relative positions of numerous islets, and this had not been known



SKETCH-MAP OF FOWL BAY COMPILED FROM FIGS. 23 AND 24.



SKETCH-MAP OF HINLOPEN STRAIT COMPILED FROM FIG. 46.

before. Upon these views is based the sketch-map of Fowl Bay which will be found on p. 86. We see from this that, when the altitude is sufficient (in this case it was about 5,000 feet) and the direction of the flight appropriate, a very small number of views make it possible to map a large extent of country.

Again, the sketch-map on p. 87 has been made from the view shown in Fig. 46, Pack Ice in Hinlopen Strait. Here we see ice-floes several kilometres across.

Returning to the consideration of the views of Lomme Bay, we see that Fig. 40 gives a view far into the bay, and shows the sinuous course of the Lomme Glacier descending from the Chydenius Mountains. Figs. 38 and 39, if taken in conjunction, give a connected panorama of the bay from within outwards. To the north (the left of the pictures), they show a plateau comparatively free from ice, with the Hecla-Hook Mountains in the background. On the south-west shore of the bay we see a plateau where the ice is somewhat thicker.

These examples, selected at random from the wealth of material secured, show the immense value of airplane photography to geographical and other scientific research.

Secondly we have to consider how far, speaking generally, the expedition, notwithstanding its

impromptu character, may be said to have furnished valuable results.

As I have already pointed out, financial considerations dictated the taking of views with a cinematic camera—views for film reproduction. This necessitated flight at a rather low altitude, where the photographs would show a wealth of detail and brisk movement. In a word, it necessitated flying between the mountain peaks. This was the main task, to the detriment of flights at a considerable altitude whence more extensive views could be obtained. Otherwise, far more material useful for scientific purposes would have been secured, the sort of material contained in the views of Lomme Bay, taken from a great height and giving distant prospects.

The material would likewise have been rendered far more valuable if stereophotographs could have been taken. It is possible to take stereo views, covering a large extent of country, in such a way that fairly accurate maps can with their aid be constructed out of hand. All that is requisite is that the height from which the separate views are taken should be noted, that the time interval should be recorded, and that the speed of flight should be accurately known. The C.P. Goerz Optische Anstalt had, in fact, provided the expedition with a suitable speedometer. In this way, by taking serial views of a strip of coast for instance, data can be obtained

for the drawing of a rough but serviceable map of the region, provided that one geographical point in the pictures be accurately known to serve as basis of the calculations. The base line can be determined by a study of the points just mentioned (time, speed, altitude, etc.). Starting from the known times, and measuring the shadows visible in the picture, approximate azimuthal determinations are also practicable.

Obviously, then, with such an equipment as that used in the Spitzbergen expedition, and in a district previously unexplored, information of the utmost value both to geographers and to geologists can be obtained.

Despite the impromptu character of the undertaking, there would have been no obstacle to the acquirement of extremely useful and fairly accurate cartographical material. Had the work been done along these lines, there would have been a yet more convincing demonstration of the work of the airplane for geographical and geological surveys. A large part of Spitzbergen is still practically unknown, and the study of these regions by ordinary methods involves great difficulty, many hardships, and serious sacrifices. By airplane photography it is now possible to learn comfortably in a few hours more than could be learned under the old conditions in the course of a whole season's work, and amid unspeakable perils and discomforts.

Lastly let us ask what could have been effected in similar circumstances by an expedition fully equipped with the armamentarium rendered possible by modern scientific technique.

When we examine the pictures actually taken, one point becomes perfectly clear (however defective the photographs may be when considered from the standpoint of geography or from that of science in general). In the whole art of geographical surveying, nothing can compete with the photograph from airplane in its power to give comprehensive information concerning wide tracts of country. For years, ordinary surveying methods have been practised in Spitzbergen, and if a complete survey by these means is practicable in that ice-bound land, it will certainly take decades more to accomplish. Obviously, then, the proper way of getting to work is by airplane photography. As will subsequently be explained, there are simple ways of elaborating approximately accurate maps out of the data supplied by such photographs. In this field, science has not been at a standstill, and we are now familiar with various methods of airplane photography to provide cartographical material. For instance, there are the methods of Hugershoff, Zeiss, and Inag. But these methods all presuppose a detailed preliminary triangulation of the country to be mapped, and nothing adequate in the way of triangulation has hitherto been carried out in

Spitzbergen. At length, however, at the instigation of the present writer, the Goerz Optische Anstalt and its daughter company the Aerogeodetic Maatschappij, have designed a photographic apparatus which makes us independent of triangulation. The apparatus works automatically, and takes both vertical and oblique views. By the simultaneous use of two instruments we can obtain utilisable views of whole strips of country extending almost from the horizon on one side to the horizon on the other. But there are advantages additional to that of the great economy of flight thus entailed. The apparatus furnishes all the data requisite for accurate cartography, without any earth measurements whatever, provided only that each photograph contains a point whose position is precisely known, so that the latitude and longitude can be marked on the map.

These or similar means will now enable the airplane photographer, in a small number of flights, to get materials from which satisfactory maps of the whole area can be drawn. Even if the ordinary methods of surveying are perfectly practicable (which, we know, is far from being the case in Spitzbergen), years of time and trouble can be saved by airplane photography.

THE FIRST ARCTIC AVIATORS

By AIRFORCE LIEUTENANT WALTER MITTELHOLZER

FOREWORD

SIXTEEN years ago, when I was still at the elementary school, I was filled with enthusiasm by my first reading of Nansen's book *In Nacht und Eis* (Farthest North). This bold deed of his, which in the long winter night and on the great ice-field, was triumphant in a world of the envious, of mockers and detractors, shone to me from afar throughout the days of my adolescence as an ideal of true manliness and courage. Away into that silent world of eternal ice and the midnight sun my thoughts and longings winged their way, accompanying in imagination the pioneers of arctic exploration, who courageously and with unconquerable determination were striving to tear away the veil of mystery in which this remote region had for thousands of years been enveiled. Ultima Thule, the mysterious northernmost ice-land of the old Scandinavian sagas, became embodied for me in this stubborn circumpolar basin, and well did I understand the irresistible impulse that drove explorer after explorer into the frozen waste. Victim after victim was sacrificed to the bitter

cold and to the furious blasts of winter; but still expedition after expedition went forth, manned by those eager to win knowledge for themselves and for future generations, eager to enlarge the heritage handed down by the hardy adventurers of the past. In this field were celebrated the most splendid triumphs of the human yearning to solve the mysteries of the Unknown, the triumphs of that undaunted spirit of research which will live on as a guiding star in a period when our civilisation seems stricken with decay.

But never, in my youthful imaginings, did I dare to dream that to my very self would it be granted, though but for a brief space, to join the ranks of these same explorers. Only in modest fashion, it is true, was this accorded, only as one of those who were to make a small contribution to the geographical study of Spitzbergen. Nevertheless, it was a pioneer investigation in this respect, that never before had circumpolar exploration been attempted by airplane. How could I dream of such a possibility in the days of my adolescence, when aviation, aerial navigation with heavier-than-air machines, was still in its infancy? A flight of a few kilometres was an unheard-of exploit, and none but dreamers and optimists anticipated any serious practical use for the airplane. I will not digress here to recount the course of these epoch-making discoveries. They are so recent, that we are

13. The Edge of the Wahlenberg Glacier in Ice Fjord, seen from a height of two hundred metres. The face of the calving glacier has a height of about thirty metres.

14. The Bore Glacier with Mount Syltoppen, seen from Ice Fjord at a height of two hundred metres. The face of the glacier has a height of about thirty metres.

15. View to the north-west from the Trollheim Plateau, at a height of twelve hundred metres. The cloud stratum is at a height of about six hundred metres. In front of John Bay is Hermann Island in the Foreland Sound. There the cloud cap has been dispersed, owing to the warm radiation from the shallow sound. In the background, Prince Charles Foreland.

16. Ekman Bay and Dickson Bay with the Andrée Quarter, seen from the south, at aheight of twelve hundred metres. In the foreground, the Foreland of Cape Wœrn. In Dickson Bay (to the right), is bay ice beginning to break up. The coastline here is continually being altered by extensive erosion and alluvial deposit.

all familiar with them—just as, alas, we are all familiar with the use of the airplane for the destructive purposes of war. Yet to the Great War it was that aviation owed its most signal successes and its extraordinarily rapid progress. Thanks to the urgency of war demands and thanks to the lavish expenditure of men and material, advances were made in a few years that would have required as many decades in the piping times of peace.

Silenced, now, the thunder of the guns. The States and the peoples have turned back to peaceful avocations. What for a while was developed as a dreaded and decisive weapon of war, has now become a means of communication whose speed will inevitably make of it a revolutionising factor in contemporary economic life. But aviation holds out other and finer gifts. The modern air cruiser reduces (in measures of time) to hours and minutes distances which but yesterday were weeks and days, thus binding ever more closely cities, countries, and peoples. To-day the airplanes fly across mountains, deserts, and seas, announcing to the dwellers in the lands o'er which they pass at headlong speed, the ideal of a new and free community of the nations.

Out of the stuffy atmosphere of the lower levels, away from the fettered existence of the surface of the earth, up into the heights, the airplane carries us, where our eyes can range

freely over distant prospects, and where we can collect into one comprehensive view all that before appeared a chaotic mass of unconnected details. Our astonished gaze penetrates the most intimate recesses of the mountains. All the secrets of the earth's crust are unveiled to the airman. It seems to us as if the world had put on a new countenance, and as if we ourselves had been gifted with new and perfected powers of vision.

The use of the airplane for the geographical study of unknown and difficult regions—assuredly this opens a new era in scientific research! When we recall how vast are the regions still unexplored by civilised man, how vast even the regions on which, so far as we know, no human being has hitherto set foot, we see what immense perspectives open. In the near future, aviation will play an important though not perhaps a decisive role in arctic and antarctic exploration. The advance of technique will gradually overcome any defects in the method. The motors will become perfectly reliable. In the very next generation, maybe, people will look back with a good-natured shrug of the shoulders to these days when aviation within the arctic circle was still a risky affair. Easily and without danger they will fly from continent to continent, and will think nothing of making their way across the polar regions whenever that happens to be the most expeditious route!

EN ROUTE

An Unexpected Proposal.—On June 9, 1923, I travelled by airmail from Munich to Berlin, intending thence to avail myself of the Junkers airservice to Danzig and Riga. In Berlin I had a talk with the director of the latter, learning that the Junkers-Hammer expedition was accessory to Roald Amundsen's proposed flight across the Pole, and that some of its members and material had already been shipped on a Norwegian steamer sailing from Hamburg to Bergen. I was also told that the utmost haste was essential, seeing that the expedition must reach the edge of the ice-pack in northern Spitzbergen by June 21st, so that it might be ready to set out instantly to meet Amundsen should he fail to arrive from Alaska by way of the North Pole.

Owing to this need for haste, which is undesirable in the preparations for any expedition, and particularly so when the expedition is to the arctic regions (where any flaws in equipment or personnel may so easily lead to disaster), the enterprise was not staffed as efficiently as could have been wished. Of the chosen participants, only one, Professor Wegener, had had any

experience of the dangers of arctic travel. Not one of the others would have been competent, unaided, to make his way homeward across the ice in the event of an enforced landing. Not one of them had ever worn snowshoes; not one of them knew anything about the conditions of travel "in ice and snow"; not one of them had been trained for long marches. But, inasmuch as our airplanes are still driven by motors upon which no absolute dependence can be placed, such requisites are really indispensable for those who venture into the icy deserts of the far north.

Junkers now asked me—it was just before noon on Saturday, June 9th—whether, at the eleventh hour, I would join the expedition as an experienced alpine aviator, ski-runner, traveller, and photographer. My surprise was a pleasurable one, and I promptly agreed to devote myself whole-heartedly to this alluring enterprise. Within half an hour, the whole matter was settled. Junkers gave me an authority which would enable me to exercise a decisive influence upon the course of events, and this naturally inspired me with confidence. But there were only seven hours left before the departure of the express train by which I should have to travel, only seven hours in which to procure all photographic and other necessaries! The firm of Goerz (which had already supplied the expedition with a number of admirable instruments), con-

sulted by telephone, was prepared to disregard the Saturday half-holiday, and to furnish me with a complete equipment for cinema photography before nightfall. The afternoon was spent in a motor car, tearing through the streets of Berlin, for there was still time to buy maps and special literature. But in spirit I was already in the far north, enjoying the light of the midnight sun, and surrounded by innumerable polar bears.

The packages, assembled from all quarters of the metropolis, made a huge pile upon the platform of the Lehrte Station, and I drew a long breath of relief when everything had been safely got into the train. All these impedimenta comprised a good deal more than my own personal requisites. There were numerous spare parts for the airplane and its engine—all that could be got together at short notice. In the corridor train I made the acquaintance of Hammer, the Seattle shipowner, and that of Fischer von Poturzyn, of the Junkers airservice. Both were on their way to Hamburg, in order to travel with me thence by seaplane across Denmark to Christiania. Urgent business on behalf of the expedition had made it impossible for Hammer to sail from Hamburg to Bergen with the other members of the staff. Professor Wegener was therefore in temporary command, and it was his arduous task during the sea voyage to initiate his companions into the secrets of arctic meteorology, landfaring, and navigation.

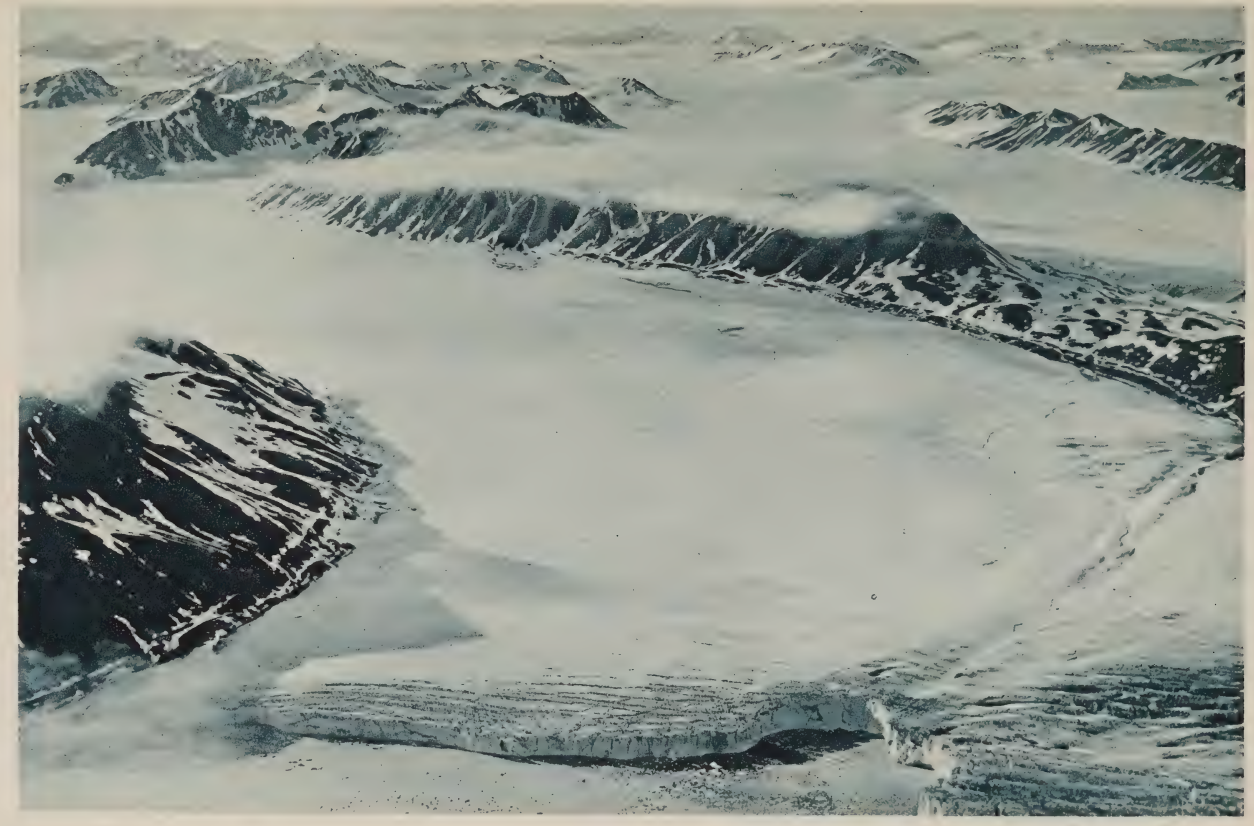
Hamburg to Hesnaes by Seaplane.—A chill north-wester was whistling through the streets of Hamburg when, at eight in the morning, we three with part of our baggage drove in a taxi to the point whence we were to start in the seaplane, Teufelsbrücke on the Elbe. The clouds were low, dark, and threatening; the foam was piled high on the shore; the weather was certainly unpropitious for aviation. The great seaplane was awaiting us at the quay; the pilot and the mechanic of D. 192 were duly dumbfounded at the bulk and ponderousness of our baggage, and at 8.42 the heavily-laden plane, helped by a strong headwind, rose laboriously out of the water. Rocking in the fierce gusts, we made our way down the broad estuary of the Elbe. At 9.7 we passed Glückstadt, and at 9.19 turned to the right along the Kiel Canal, still flying very low (about 50 metres) because of the overhanging clouds. On either shore of the canal stretched land as flat as a pancake, heath interspersed with peasant farms, where cattle were grazing in the pastures. From time to time we flew over ocean-going steamships, which had a strange aspect amid these rural scenes. In just under an hour and a quarter from the time of leaving Hamburg, we reached Kiel, where Pütz, our pilot, planed down to the water, having to restart his engine from time to time to avoid being driven back by the raging headwind. At 9.55 we

" grounded," striking a huge wave with a mighty splash, and alighting in front of a disused steamer lying at anchor. Thence, rolling and pitching, at half speed to the sandy shore, for the customs examination before leaving German territory.

By 10.55 all was ready for a renewed start. The weather conditions had not improved meanwhile, for the wind had freshened and visibility was poor. But we were in sheltered waters, so the sea was not high, and, helped of course by the headwind, we rose with unexpected ease. Steering north-eastward out of Kiel Bay, we soon lost sight of the line of foam along the shore, and could see nothing but open water. Now, therefore, we had to guide our course by compass. Soon, Fehmarn Island came in sight to the south-east. We flew quite low as we passed it, only a few metres above the water, and speedily lost sight of land once more as we crossed Fehmarn Belt. Now a fishing-smack hove in sight, heeling over in the wind, and crossing our path on a westerly course. Flying just high enough to clear her masts safely, we waved greetings to the crew as we passed over her with the speed of an arrow. This was but a moment's vision, and for some time now the pilot had enough to do to keep his plane stable against the furious onslaughts of the wind. At length, by 11.40, we reached the southernmost point of the Danish island Laaland, and my companions and

I were gratified to see from an examination of the chart that there was no further likelihood of our losing our way. Now we need merely hug the coast, rounding the south of Falster, and then bearing northward along the eastern shores of Falster, Möen, and Zealand, to reach Copenhagen, where we were expected. But already, while crossing Fehmarn Belt, we had heard a good many misfires, and at this juncture, when they became more frequent, Pütz began to test his switches. Thereupon the engine stopped altogether. Magneto trouble, or smoked plugs! Nothing for it but to come down! Making for the neighbourhood of a sandy beach, Pütz took the water at 12.55. We came down rather roughly owing to the violence of the waves, about two hundred yards from the shore, towards which we drifted. Some friendly fishermen, who helped us to moor our machine, informed us that we were close to the village of Hesnaes on the island of Falster. The pilot and the mechanic hastened to trace out the source of trouble, and to put things to rights—it was a failure in the connexions with the magneto. In half an hour everything was ready for a fresh start, but a preliminary test of the engine with open throttle showed that it was capable of only 1,300 revolutions instead of 1,350.

By half-past-one, all was said to be in order. As a land pilot I was eager to see how a start could be made from such stormy waters; and I



17. The Konow Glacier with the Löwenskjöld Plateau, seen from the south-west, at a height of twelve hundred metres. Note the rounded, hummocky aspect of the end of the leftward range of hills. This indicates glacial erosion, and shows that at one time the Spitzbergen icefields were far more extensive than they are now.

18. Mount Holta with Prince Charles Foreland, seen from the north-east, at a height of twelve hundred metres. Upper surface of clouds, about seven hundred metres.

was, it must be confessed, somewhat sceptical. As soon as we were tossing once more upon the high sea, Pütz turned the plane to face the wind and opened the throttle to the full. There was a deafening clatter; the waves struck blow after blow, making the machine tremble in all its joints. To make the rising easier, Hammer and I betook ourselves to the front wall of the cabin, close to the centre of gravity of the seaplane. We had to hold fast, in order to avoid being flung across the cabin. But all was in vain. Every time that we seemed on the point of clearing one of the waves, we struck the water once more with a shock, for we could not get up enough speed to give the planes sufficient lifting power. Now Pütz made a fourth essay, determined at all hazards to force his machine to quit the heavier and more resistant element. Once more, failure! At a speed of ninety kilometres (fifty-six miles) per hour, when, with planes set to rise as rapidly as possible, we began to skim the billows, it was only, after a lift of a couple of metres, to run full tilt into an oncoming and towering wave. A frightful crash followed, with a metallic crackling; and for a few seconds our watertight cabin was actually submerged. We were hurled from our seats, and the trunks were shaken like dice in a dicebox. The pilot and the mechanic, exposed in front of the cabin, were drenched. In a moment or two, however,

our water-bird righted herself, and breasted the waves once more, showing that the floats and the chassis or undercarriage were intact. But something had gone wrong with the port wing! Yes, in the outer third it had been broken clean off. The loose end was trailing in the water, attached only by the steering cable. Further flight was out of the question, and we might think ourselves lucky should we be able to reach the shore at Hesnaes, more than half a mile away. In the end, though rather slowly, we managed this, for the propeller was uninjured. The good folk on land had been following our evolutions with interest not unmixed with alarm, and the fishermen were ready in their boats to give us all the help that we needed.

Despite this misadventure I rejoiced inwardly at the seaworthiness and toughness of the Junkers seaplane, for I never could have believed that a machine of this kind had yet been built able to stand such rough usage as ours experienced during the ten minutes of our four unsuccessful attempts to rise into the air once more. My chief regret was that Professor Junkers, the constructor, had not had the pleasure of being with us on the occasion. Had there been no engine trouble, had we had the missing 50 revolutions and had we been less overloaded, there can be no doubt that the machine would have been fully equal to the occasion, and that

notwithstanding the severe buffeting, the seaplane would have successfully resumed aerial flight. The incident gave me absolute confidence in the Junkers plane—and the pilot needs such confidence when he is to fly in unknown regions, and far from the haunts of men.

Hesnaes to Christiania via Copenhagen.—Pilot, mechanic, and seaplane were left at Hesnaes, to wait for a new wing from Dessau. For our part, we quickly requisitioned a private motor car for ourselves and our baggage, and drove through beechwoods and oak forests, past admirably kept farmsteads, to Stubbekjöbing, the nearest station, where we caught the Copenhagen express. We reached the Danish capital at half past seven, to be greeted there by a large company of persons who had already heard of our mishap. The hour and a half we spent in this city were devoted to newspaper interviews. Indeed, the press photographers had taken us by storm already, the instant we set foot upon the platform. The forced landing at Hesnaes became a nine days' wonder. The papers were full of imaginative pictures of the broken-winged seaplane, with libellous portraits of Hammer, Fischer, and Mittelholzer duly attached.

I was glad to get away from the hubbub, to bid farewell to Denmark's gay and beautiful metropolis, and to take refuge in our sleeping

car. Cradled in an upper berth, nestling between spotlessly clean sheets, when the train pulled out at nine in the evening, I was in a place where the omniscient newspaper reporters ceased from troubling and the weary could get rest. Lulled by the monotonous hum of the wheels, I could fancy myself once more in the seaplane, flitting over the crests of the waves. I could again live through all the sensations of an adventurous day, and dwell in imagination upon the interruption to our flight at Hesnaes. At length sleep brought relaxation of tension, and I did not wake till late next morning. By then we were well up the west coast of southern Sweden, rolling northward through green forests, across romantic heathlands, and between blue-tinted lakes and deep indentations of the coast. By noon we were in Christiania, to find there that the spring, a late and chilly visitor that year, was so much behindhand that the lilac and the fruit trees were only just beginning to bloom.

Three Days in the Norwegian Capital.—We spent three days in Christiania, and here there was still a good deal of work to put through on behalf of the expedition. Hammer and Fischer von Poturzyn made the necessary arrangements with the authorities and dealt with the pressmen, leaving me free to remedy the defects in my outfit. When all was in order, I had time to visit Holmenkollen, the famous skiing centre,

having the pleasure of the company of some friends of Roald Amundsen. From this place there is a magnificent view of the town, the snow-clad mountains, the sea, and Bunde Fjord where Amundsen's home is situated. A unique prospect! The colouring was rough and vigorous, as is characteristic of the north, blue predominating; the deep blue of the sea, shining like silk; and, overarching all, the translucent ethereal blue of the firmament. The sunlit air was laden with the resinous odour of the surrounding pinewoods. . . .

On June 12th we received by airpost the remaining spare parts, those with which we had not ventured to load our own plane when we left Hamburg. On the 14th, therefore, we were able to leave by the night express for Bergen, reaching that port at noon on the following day.

The Members of the Expedition Foregather in Bergen.—The other members of the expedition had arrived two days earlier in a Norwegian passenger steamer. They had had rough weather, and had most of them been seasick. There had been a risk for a time that the airplane, which stood fully mounted on the poop-deck, would be washed away. But the metallic wings had successfully withstood the onslaught of the waves. The machine was uninjured, and was safely transferred to the quay.

In the Norge Hotel, Fischer von Poturzyn

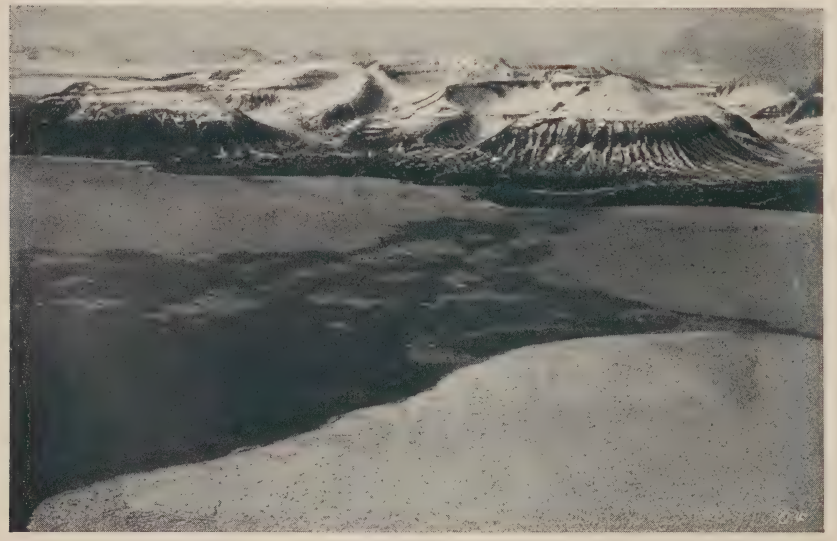
introduced me to my new companions. In my secret heart, I was chiefly interested in Neumann, with whom I was to be so closely linked in good times and in bad. I found him strong and congenial, a man with a kindly smile, rather of the sea-bear type, one who had spent most of his life at sea. In the early days of the war he was a junior officer in the imperial navy. Then, with the development of seaplane work, he became air mechanic and subsequently air pilot. After the collapse of the German army, he turned to civil aviation for a livelihood, and from 1921 onwards worked as pilot in the Junkers airservice. It was obvious that Neumann was not built to endure great bodily hardships, but his quiet and controlled demeanour bore witness to a temperament sustained by unexhausted reserves of nervous energy—that mysterious energy of which the airman, if he is to be always equal to the occasion, must have an ample store in the potential form.

Neumann and I soon became good friends, fundamentally different though we were in outlooks and disposition. He was fond of the busy life of a great seaport, and was never weary of talking about Hamburg, his native city. When, in return, I tried to give him a faint idea of the charm of my own homeland, to picture for him the sublime grandeur of an alpine landscape, he would shake his head incredulously. How could

19. The Dalsland Range with the Trollheim Plateau from the south-east. To the left is the Esmark Glacier; to the right, the Nansen Glacier. The shapes of the hills are due to the gorge-cutting action of the ice (garland forms). In the background we see Prince Charles Foreland, distant about ninety kilometres.

20. The Nordenskjöld Glacier in Billen Bay, seen from the west, at a height of seventeen hundred metres. The face of the glacier has a height of about thirty metres. In the left background, De Geer Mountain; to the right, the lofty glacier plateau.

21. View from the Holtedahl Plateau towards the south-west, from a height of fifteen hundred metres. Upper level of cloud stratum, about six hundred metres. In the background, Prince Charles Fore and.



22. The western shore of Dickson Bay, tertiary, with columnar formations. Little glacier formation. A broad river delta. Bay ice breaking up.

any sane man find pleasure in the troubles and dangers of mountaineering? No oratorical arts could make this comprehensible to the dweller in the plains and on the sea, who had never before seen a mountain. But when we had been in Spitzbergen together, when we had flown over dazzling glaciers and rocky crests, glowing and flaming under the midnight sun, he carried home with him some notion of the way in which hill-men desire their hills.

We had to spend three days in Bergen awaiting the arrival of the Norwegian collier "Eidshorn," which was to take us to King's Bay in Spitzbergen. She was on her way from England, and had been delayed by the stormy weather. We had, therefore, time to become more closely acquainted with this romantic old town, where, in the fifteenth and sixteenth centuries, was one of the chief trading settlements of the Hanseatic League. The tall, gabled houses are built upon what used, long ago, to be the sea-shore. Professor Wegener and I climbed Flöien, whence there is a splendid view seaward across the intricate system of fjords amid which Bergen lies. Returning to the port, we admired the sturdy whaling ships and the boats of an older type like those of the days of the vikings. Wegener was an admirable guide. He has an expert's knowledge of the sea and of all those who go down to the sea in ships and do business in great

waters, and I, who am from an inland country, listened eagerly to all his maritime lore. I have also a pleasant memory of hours spent with the staff of the Geophysical Institute, and in especial with its director, Professor Helland-Hansen. From these gentlemen I learned much which has been of the utmost value to me. Professor Helland-Hansen was good enough to fit us out with some scientific instruments which were still lacking to the expedition, and I wish to take this opportunity of thanking him once more.

Voyage up the Coast of Norway.—Sunday, June 17th, was a glorious day. The sky was cloudless, and the weather was warm—for the first time this year. A wireless message had come to the effect that our ship might be expected that evening. Airplane, petrol stores, cases of instruments, spare parts, provisions, personal baggage, everything was carefully ranged on the quay. The only lack was the steamer, for which we were so eagerly waiting. She did not come in sight, far down the fjord, till ten o'clock, when the rocky hilltops were glowing red in the sunset; and she was not made fast to the quay till half past ten. Now there was an animated scene. In a hand's turn, the mighty crane transferred our airplane to the fore-deck; the cases of petrol and all the rest of our goods soon followed. A large crowd had assembled to witness the unwonted shipment. Before midnight, everything

was on board; the ropes were cast off; the siren howled the signal for departure. Final greetings were waved to the friends and acquaintances who had come to see us off, while slowly and majestically the ship steamed forth into the twilit night, bearing us towards the great unknown. I stood entranced on the upper bridge, drinking in the incomparable charm of this clear, warm summer night of the north. The sky had a wonderful translucent tint, a chiaroscuro that was neither day nor night. In this fascinating and peaceful half-light every detail on the shore remained visible. To the north-west the soft blue of the zenith merged horizonwards into a delicate pink; to the south and the east, into a pale green. The spindle-shaped clouds, bad-weather portents, were of a copper tint, and were mirrored in the waters. White-sailed yachts and smaller boats in plenty, pleasure boats of one sort and another, passed us on their homeward way from their Sunday outing, laden with happy folk. I could understand at last why the Norwegians would not exchange their midnight sun for all the splendours of the south, and why their land is just as dear to them as Switzerland to us who dwell in the Alps. Tired out though I was, it was long before I could make up my mind to seek my cabin. I breathed in all this beauty like a refreshing balsam, and was loath to close my eyes to the sight.

Now for four days and four nights we steamed

northward, by sunshine and rain, though narrow sounds and amid rocky islets, past lovely fjords, along the most beautiful coast in the world. At times we were far out on the stormy sea, and at other times in quiet channels betwixt island and mainland, where cheerful gardens sloped down to the water's edge and the dark-red houses gave the scene a warm human touch. Often enough I could fancy myself in a Swiss valley, on the shores of the Lake of Lucerne. A beautiful, a glorious country, this Norway. Happy and contented are the folk who people its shores, where the force of the waves of the western ocean is tempered by the natural breakwater of the granitic islands tumbled pell-mell along the coast. Some of these are rough and rocky, with no more than a thin stratum of moss-grown soil here and there; others are rounded, comfortable-looking, habitable, and inhabited. Beyond the nearer ones, whose tints and shapes are perfectly distinguishable, range others whose outlines are already fading in the distance, and yet others which are little more than blue walls of haze at whose foot the line of white breakers can still be distinguished. Such was the endless panorama of our northward voyage: on the one hand, the thousandfold islands, close at hand, in the middle distance, or at the horizon's verge; on the other, the dark, precipitous mountains, ever-changing likewise, with brilliant snow-and-ice-caps thrust-

ing in ghostly fashion upwards above the cloud-drifts. The sky was overcast when we passed Torghatten, which looks like a huge fortress, and where the rock is pierced by a vast natural tunnel 400 feet above sea-level. As you go northward, the snowline lowers, and here the slender pyramids of the Seven Sisters scale the heavens, sublime in their loneliness and whiteness.

A Change of Plan.—Just as we crossed the arctic circle, we received a wireless message to the effect that Amundsen had abandoned the design of flying across the Pole that summer. The reason obviously was that his machine, which had been in the Alaskan snows since the previous autumn, was no longer workable. I learned afterwards that the plane had been refitted in the United States with a new undercarriage, and that this was what was at fault. Amundsen's own words are : " The machine was excellent, and all was in perfect order. When we made a trial flight, the prospects of success seemed most encouraging. But the new undercarriage, built by Larsen for the runners, was too weak. When we landed from our trial trip, it broke up. . . ."

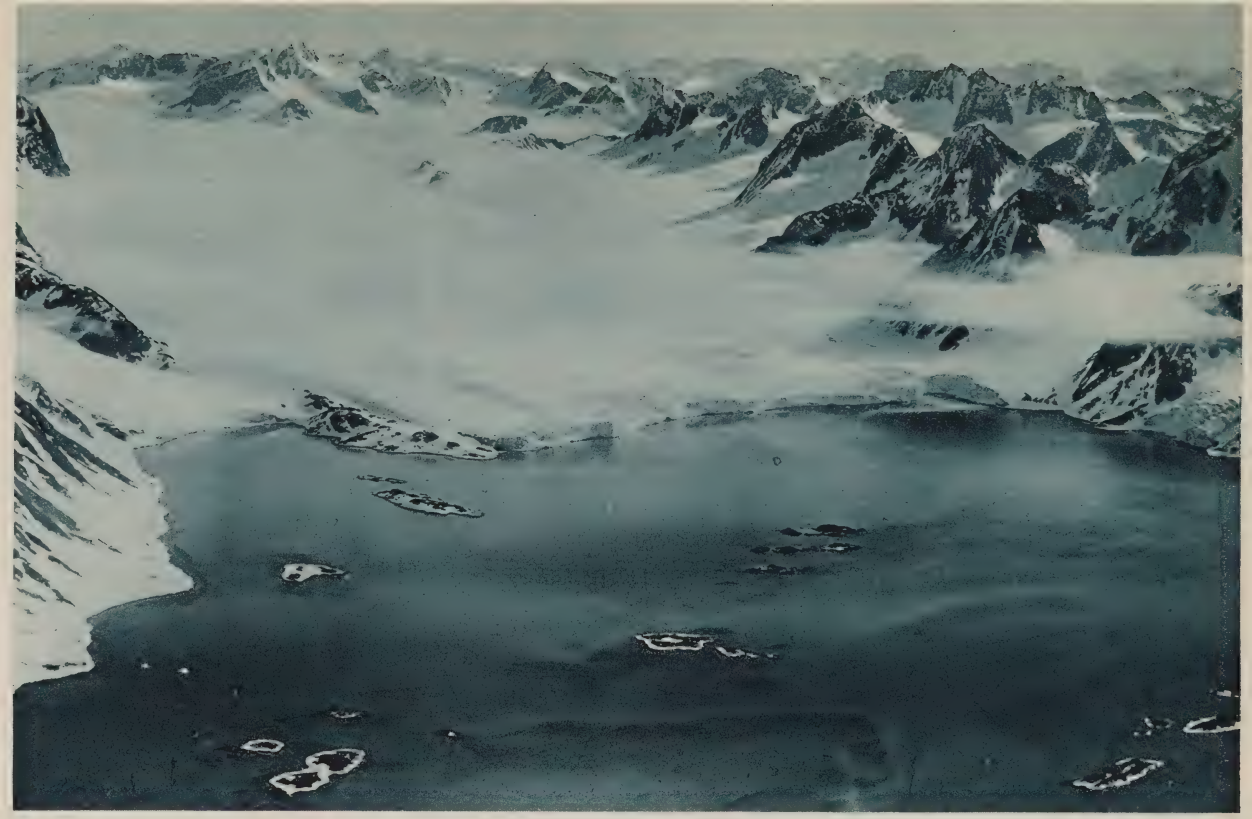
Thus the original aim of our journey no longer existed. Nevertheless, after talking matters over, we decided that, since we had got so far on our way, we would not turn back from the journey to Spitzbergen. It would still be a good thing to under-

take the practical study of arctic aviation, and to take photographs of this little-known region.

An entirely new situation was now to be faced, and it was one far more to my taste than would have been the task of searching for Amundsen if he had started from Alaska and had failed to reach Spitzbergen on June 21st. Though I had kept my doubts to myself, I had been very dubious of the possibilities of success in any such search. I could not imagine, especially when I recalled Nansen's description of the ice-pack, that there would be much chance of happening upon one lost traveller in this vast desert of more than fifty thousand square kilometres—for this was the extent of the area in which the search would have to be conducted. Great, too, would be the risk of perishing of cold and hunger, should a landing upon the ice-pack become necessary !

This new venture was far more promising. With reasonable luck, we could hope to make a modest success of our scheme to achieve a geographical survey of Spitzbergen and North East Land. There was good reason to hope for a positive result, for something that would help to open a new and valuable field for aviation.

Tromsö and Its Surroundings.—At midnight on June 21st we reached Tromsö. On the snow-clad hills towering to the south of the Rystrom the red glow of the midnight sun flickered spectrally



23. Fair Haven, Fowl Glacier and Mount Vesteralen, seen from the north, at a height of fifteen hundred metres. In the foreground, the Schären Islands, formed by glacial erosion and the subsequent retraction of the glacier.

24. Fair Haven. The rightward continuation of Fig. 23.

here and there. Dark, violet-tinted cloud shapes were chasing one another across the sky. The anchor-chains clattered through the hawse-pipes as the anchors were let go. A cold wind from the north was whistling through the sound.

Rather sleepily we set to work upon the unlading of our goods. First of all the great sea-plane was hoisted by the steam crane and lowered into the swift current. Already, on board, Neumann and Holbein had been at work, making sure that all was in order, and letting the engine run freely to warm itself up. Now the pilot had merely to turn the starting magneto. The engine started, the propeller revolved, and our great bird glided across to the Tromsö mole, and down towards the forest of masts in the harbour where, firmly moored side by side, lie the stout arctic whalers—always recognisable by the "crow's nest" or look-out barrel on the mainmast. Meanwhile all our baggage had been transferred to a lighter. Having said farewell to captain and crew, we went ashore in a motor boat. By five o'clock in the morning everything had been safely stowed on the quay, so that at length, by now pretty well tired out, we could seek a resting place in the sleeping town.

Our next business, after a rest, was to hunt up transport facilities. The first idea was to charter a fifty-ton cutter, which was going cheap owing to the decline in the fishing industry.

This would have involved dismounting the seaplane, which could not have been loaded entire upon so small a vessel. The dismounting in Tromsö would have been an easy job enough; but the refitting in Spitzbergen, far from regular workshops and efficient appliances, was a formidable prospect. While we were still hesitating, a much better solution of the transport problem offered itself. We were calling on Mr. Krognes, director of the Tromsö Geophysical Institute, and learned from this gentleman that he had just been informed by wireless of something likely to help us out of our difficulty. The Dutch collier "Ameland" was expected at Tromsö towards the end of June. She would there ship about a hundred Norwegians who were to work in the Dutch coalmine at Green Harbour. On hearing this, Hammer telegraphed to the mining company's head office in Rotterdam to ask for a passage upon the steamer, which was big enough to take the seaplane intact. A favourable reply was received next day.

Now that all our cares were removed by this stroke of luck, I could give myself up to the agreeable task of becoming better acquainted with Tromsö and its environs. On the neighbouring mountains the snowline was about 150 metres (500 feet) above sea-level, and from here up to a height of 1,200 metres (4,000 feet) or more the snow was in perfect condition for ski-

running. It was, in fact, of the consistency which rejoices the skier's heart. Every day I took the ferry across the sound, and walked through the thin birch forest (now turning green) to reach the snowfield. The mean temperature was a few degrees above freezing point.

Immediately on arrival I had been interested in the Tromdalstind, the fine pyramidal snow-capped peak in Tromsdal. On June 28th I climbed the hill, 1,238 metres (4,080 feet) in height, from the sea-level in three and a half hours. Except for one very steep part of the climb, which was quite short, I wore ski all the time. Our host in Tromsö, concerned for my safety, had sent a Norwegian guide with me, but this companion turned tail at the foot of the ascent, saying that the hill was too steep, and in summer too dangerous owing to the risk of avalanches. The other members of the expedition, whose taste for climbing was fully satisfied in the foothills, followed my progress through their field-glasses. When, after a breezy rest at the top, I came down with a rush, the snow-dust flying from my skis, it was obvious that I had gone up a peg or two in their respect. The view from the summit was magnificent. (See Figs. 2 and 3.)

On June 26th, Wegener and I set out upon a three days' journey along the fjords. Heavily laden with food, skis, and cameras, we took a little coasting steamer up the long Bals Fjord.

Thence on foot through lovely birch forests and past isolated homesteads to a fisherman's hut near Koesmenes at the upper end of the gloomy Lyngen Fjord. Here we had good entertainment from simple but cultured folk. Our host was a trader as well as a fisherman. The Lapps, who wander through these regions with their reindeer herds, barter reindeer hides for firearms, cartridges, and textiles.

Very lonely is this mighty mountainous land, where nature and man are equally unsophisticated. On either side of the fjord the cliffs rise sheer to a height of more than 300 metres (1,000 feet). At the foot, by the water's edge, runs, like a green ribbon, a strip of birch forest. In the valley of the Sördalvselv, some families of Lapps had just pitched their greasy tents. I visited the settlement. These freedom-loving nomads were rich in the possession of a herd numbering more than a thousand reindeer.

Next day we had to bid farewell to this magical spot. The steamer makes its round only once a week, and we could not delay another week before returning to Tromsö. There is no landing stage, and we went off to the steamship in a big rowing boat, laden with reindeer hides, fish, and a live cow, as well as our precious selves. That day our voyage lasted seven hours, to the island of Skjaervö by way of Lyngen, Ülo, and Mauersund, past hamlets with green meads,

and past shimmering glaciers lying between granite walls. Next day we got back to Tromsö.

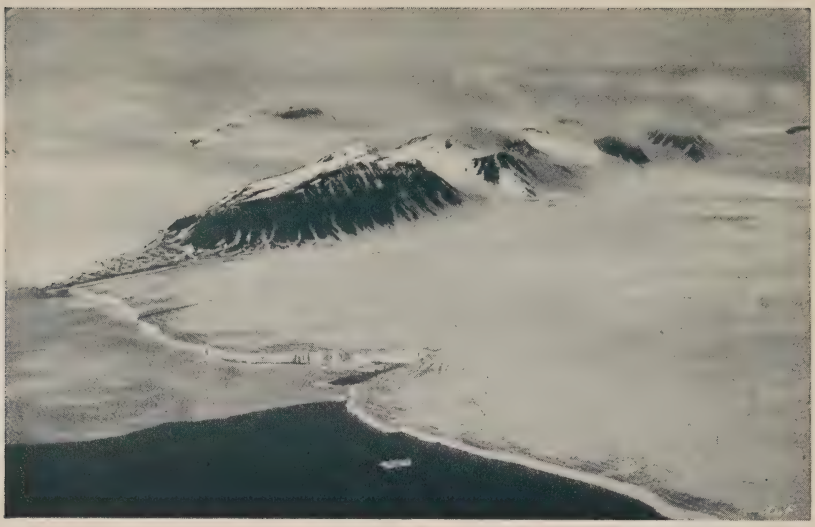
Meanwhile the other members of the expedition had been carefully overhauling the seaplane, to make sure that everything was in perfect order. On a clear day we took a trial trip—a wonderful spectacle for the dwellers in what is, but for Hammerfest and one or two lesser places near the North Cape, the northernmost town in the whole world. A large crowd assembled on the quay to admire the ease and grace with which our seaplane rose from the water. On this flight I grasped for the first time the insular nature of Tromsö, a green oasis in a sterile-seeming, ice-cold sea. Across the sounds there now appeared other islands, hitherto unseen, with steep and lofty peaks that of old, in the Ice Age, must have projected through the universally levelling icefield. To-day their jagged crests, thrusting heavenward above the surrounding hummock-shaped and ice-clad hills, stood out in violet-tinted contrast against the yellowish red of the north-western sky. The dark sealine seemed to rise with us in our ascent, till at length, behind the mountains of the Kall Fjord, the sea seemed to stretch away into the infinite. Far to the north I could plainly discern the steep declivities of the island of Fuglö, nearly 100 kilometres (60 miles) away. So distant a view, in a clear and pure atmo-

sphere, free from watery haze and dust, was for me a rare experience on aerial journeys. In Switzerland I had known it on one or two occasions only, when the föhn had been blowing. But at such times flying is not a pleasure, for the airplane is tossed by the blast like a cork upon stormy waters. Here, in the land of the midnight sun, the air-currents were gentle and barely perceptible. I had, therefore, an excellent opportunity for testing my photographic apparatus. With Neumann's goodwill I was able to practise the different aerial evolutions which are indispensable to successful photography from airplane (this corresponding to the search for a suitable location for the camera, when a landscape has to be photographed from the firm ground). Neumann and I had to drill together for a good while, after talking matters over in detail. In my work as photographer from airplane, I have always found a complete understanding between photographer and pilot of supreme importance. Only by that means is it possible to secure satisfactory views in the shortest time; and, in the case of cinema work, to achieve the requisite variety and contrast.

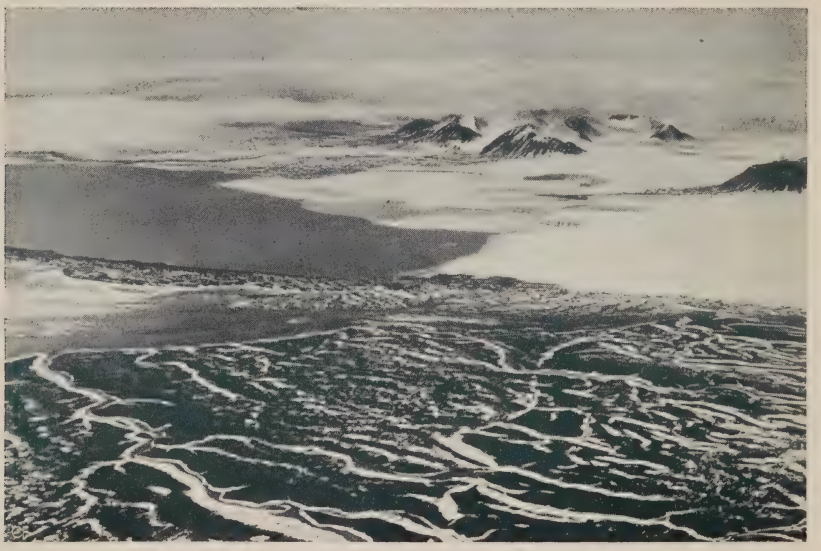
Every year a scientific expedition is sent from Norway to Spitzbergen, to carry on geological and cartographical researches during the summer months. Under the leadership of Professor Adolf Hoel (who has been good enough to

25. The Firn Plateau with Nunataks. Looking northward, from a height of twelve hundred metres. In the left background, the Queens and the Three Crowns. Diadem in the back centre.

26. The same, looking southward, from a height of twelve hundred metres. In the foreground, the Firn Plateau, with its glaciers. Behind this, on the left, the Trollheim and Alkhorn Mountains, with fine ravines, scooped out by glacial action. Farther back on the left, Cape Staratschin. In the background, clouds over the sea.



27. The Bore Glacier, from a height of eight hundred metres. Glacier face, thirty metres. On the glacier, runnels of water and areas of slush. Left foreground, bay ice, about one metre thick. In the middle of the picture, the Gestrikland Chain. Behind this, the Nansen Glacier.



28. An almost identical view, but from a greater distance, and from a height of only five hundred metres. The Boheman Tundra and the Ekman Tundra.

write a preface to the present book), the members of this expedition had now reached Tromsö. We all foregathered in the hospitable home of Mr. Krognes, hard by the Geophysical Institute, high above the town. Here we spent interesting and enjoyable hours, learning much that was of the utmost use to us in our work. Professor Hoel's own interest was probably aroused when he heard of the enterprise upon which we were engaged, for one of his main tasks is the cartography of Spitzbergen, and he was convinced that our projected photographs might be a most valuable contribution.

Crossing the Barents Sea.—At length, on June 30th, the Dutch collier arrived. Next morning at 10.30 we left Tromsö. It was in cold and rainy weather that the "Ameland" steamed out of Tromsö Sound, down the long fjords, and then by way of Hammer Fjord into the open sea. The poop had been temporarily converted into a bunk-house, with berths in three tiers for the 150 miners. The seaplane, therefore, was on the foredeck, where it occupied the whole breadth of the ship, its wings having a span of 8 metres (26 feet) each. Its cabin was my habitation during the greater part of the voyage. The weather was showery and a raw wind was blowing when the last rocky islets of the European coast sank below the horizon as

we steamed northward across the smooth waters of the Barents Sea. Seated at ease among the leathern cushions, I studied the literature of Spitzbergen. I spent the night in the same retreat, but did not sleep long, for the persistent daylight and the cold were not conducive to slumber.

By one o'clock on July 2nd the weather had cleared, and we sighted Bear Island about twenty miles away, this showing that we were already half way to Spitzbergen. At 5 p.m. we suddenly entered a thick and chilly fog. That was my first experience of this terror of Arctic navigation. I had read much about it, and knew that the dangers it concealed had sent many a stout ship to the bottom. There must be floating ice close at hand, and the greatest care was needed. We reduced to half speed. The siren wailed at regular intervals, and in the bows two of the seamen were constantly on the look-out, peering forward into the mist. Now, to starboard, a dull sound was heard. Was it the distant echo of our own siren, or was it the warning signal of another ship ? The noise drew nearer, and was certainly from the siren of a vessel steaming towards us. Our engines were stopped ; there was silence for a few moments ; then the raucous blasts of our own siren were resumed. A strange invisible encounter upon the lonely waters of the polar sea ! Gradually, now, the signals of the other

ship faded away in the distance. Half speed again, for the immediate risk of a collision was over. But our own warnings must continue, and no sleep was possible so long as the fog lasted. Yet the fog-belt was only a few feet thick, in its vertical extension. In the zenith the blue of the sky was plainly visible.

In the airplane's cabin that night the cold also helped to keep me awake, so next day I tried to make up the arrears of sleep in the ship's cabin astern. Here the atmosphere was far from alpine in its quality, but the liveliness of social intercourse was to make up for the lack of fresh air. In one corner a man who had been a schoolmaster in Germany was playing melancholy airs upon the fiddle ; his own poverty had driven him forth from his temporarily impoverished land. Three Norwegians were grinding out national airs upon a hand organ. Some were whiling away the time at cards. Others were apparently trying to drown their sorrows by frequent application to pocket flasks. On the opposite couch to mine a German medical student was lying and reading. He had hired himself out to the mining company in the hope that, later, the hard-earned money could enable him to continue his studies.

On July 3rd, at 5 a.m., we encountered large masses of drift ice, and had to make a detour towards the south-west. At 9 a.m., from the upper bridge, I could see the gleaming edge of

the ice, looking from this distance like the great white crest of an advancing wave. Scanning the ice with field-glasses, I could make out the crow's-nests of a number of whalers. Soon we began to pass among ice-floes, from 30 to 100 feet wide; and upon some of these, seals were disporting themselves. In the distance was a whale (now becoming rather a rarity) spouting from time to time. We had reached the peopled quarters of the polar ocean, the region that has been much visited by whalers ever since the hardy Dutch navigator Barents discovered Spitzbergen in the year 1596. At three in the afternoon we sighted land on the starboard bow. This was the southern part of Spitzbergen, near Bell Sound. The weather was clearing nicely, and the coastal mountains and glaciers showed up admirably as we neared the land. More and ever more imposing looked the serrated range with its wealth of colouring behind the monotonous tundras of the foreshore. At 9 p.m. we entered the great Ice Fjord. Here, in bold relief on the northern steep, was the Alkhorn; and beyond it, to the north-west, across the Foreland Sound, was the formidable rocky ridge of Prince Charles Foreland, shining ruddy gold in the late evening sunlight. Spitzbergen was arraying herself with all her charms in honour of our arrival.

IN SPITZBERGEN

First Impressions.—At 10 p.m. the "Ameland" made fast to the wharf of the Dutch coalmines, and we were able to land. It is always a great day for the colonists when, after the long winter, the first ship comes in from Europe bringing, not only the much desired letters, but an ample supply of the thousand and one things to which civilised human beings are accustomed. We, indeed, were not the first comers. There had already been one vessel that season. But, in addition to the new miners, the "Ameland" was bringing cattle, and large quantities of wood for the building of quarters for the workmen.

While the newly-arrived miners were busied conversing with the old hands, and learning all they could about the working conditions, some of us strolled along the narrow strip of sand to the wireless station about a mile and a half to the southward. The tall masts had already attracted our attention as we steamed up the fjord. Here, besides the recent one-storied wooden buildings of the Norwegian wireless station (see Fig. 5), there are about half a dozen

crumbling shanties, and on the shore the remains of the blubber-boiling factory with its long chimneys of iron piping. This was in use till about ten years ago. The harpooned whales were towed here, the blubber was cut off, and then boiled down in huge vats. The flesh, regarded as worthless, was simply thrown back into the sea, where it was welcome provender for myriads of seabirds. Half-cleaned skeletons of whales still lie on the strand, to poison the air summer after summer at each successive thaw. The whaling station has been deserted, for the whales have been almost exterminated by reckless fishing. In Spitzbergen waters, at any rate, where they used to exercise the same lure as gold in the goldmining districts, they are now rare, and the lucrative days of northern whaling are over. Among the skeletons of whales, putrefying remnants of whale-flesh, and heaps of rusty tins, we found the most suitable and safe harbourage for our airplane, still mounted upon floats. Close at hand was a wooden hut where four members of our expedition could be quartered. Wegener, Hammer, Löwe, and I preferred a more distant hut, at a somewhat higher level, a hut which had formerly belonged to the Anker Coalmining Company. Here we should at least escape the offensive smell of rotting blubber, and we could enjoy a lovely view of the whole extent of Green Harbour.

29. Chydenius Mountains with East Fjord in Wyde Bay, seen from the east, at a height of seventeen hundred metres.

30. Cross Fjord and King's Fjord, with Prince Charles Foreland, seen from the north, at a height of twelve hundred metres.

The rest of the day (it was already midnight!) was spent over a friendly glass in the agreeable company of the five Norwegian wireless employees. It was not till late next morning that we returned to the ship.

The fourth of July was cold and foggy. We spent the day unlading our baggage, and transferring all to our new quarters. For the miners, two hundred or more in number, the great event was, of course, the unshipping of the airplane, and its subsequent flight to the former train-oil factory. Most of these men had never before seen an airplane, and they stood open-mouthed watching the flight of the great sea-bird. Nor was this the only occasion when mining work was interrupted. The chief engineer of the mine declared that our stay in Spitzbergen was marked by a notable decline in the output of coal!

The Seaplane and its Equipment.—Before I pass to the account of our flying activities, I should like to give a brief but somewhat technical description of the airplane (see Fig. 7).

The Junkers metallic monoplane is constructed exclusively of metal, the framework, the wings, and the cabin being of duralumin, which is a variety of aluminium bronze (aluminium alloyed with copper and manganese). The engine in our machine was a B.M.W. motor (made by

the Bavarian Motor Works in Munich), of 185 nominal h.p., but its effective h.p. was somewhat greater. The total span of the wings was 17 metres (55 feet), and the total length fore and aft 10 metres (33 feet). The superficial area of the lifting surfaces including the rudder was 45 square metres (484 square feet). The net weight when fitted with a wheeled undercarriage was 1,200 kilogrammes (2,645 lbs.); when fitted with floats it was 1,380 kilogrammes (3,040 lbs.). The maximum additional load was 600 kilogrammes (1,320 lbs.), and with this load in straightforward flight at the sea-level a speed of 150 kilometres (94 miles) per hour was attainable. The fuel consumption was exceedingly small, ranging at 30 kilogrammes (66 lbs.) per flying hour. No other airplane has yet rivalled the Junkers in this economy, which is mainly due to excellence of wing design. Our machine was one of the J. series (J.13), machines of these types having been turned out for years by the Junkers works at Dessau, and being used on various regular airlines both in Germany and abroad. The main tank carried fuel for about six hours' flight. In the cabin we also had (in place of the front passenger seat) a supplementary tank carrying fuel sufficient for another twelve hours' flight. In case of need, therefore, a sustained flight of eighteen hours was practicable. This modification had been made with a

view to the search for Amundsen. The top of the supplementary tank, which extended right across the cabin, was fitted up as a chart and instrument table.

In addition to the usual instruments with fixed attachments to the airplane, I had brought the following:

A driftmeter, made by the Goerz Optische Anstalt. With the aid of a stop-watch and a knowledge of the altitude, by the use of a table the speed and the drift of the plane could be worked out at any moment, even when passing over monotonous snow-covered surfaces, clouds, or the sea.

A quadrant with an artificial horizon for taking the altitude of the sun, so that, with the aid of a chronometer and of astronomical tables, the latitude and longitude could be determined.

Two pocket chronometers.

Two liquid compasses cardanically mounted: one in the middle of the pilot's compartment, the other low down on one of the wings.

The photographic equipment consisted of a Goerz-Hahn cinema apparatus with a fitment for 120 metres of film; also an airman's camera for pictures of 13 × 18 centimetres, with a focal distance of 24 centimetres; also a small and very handy roll-film camera with a focal distance of 18 centimetres. Both of these cameras were by Goerz. The cameras were provided with magazines holding 120 plates.

A Friendly Call by Airplane.—At six o'clock in the evening of July 5th, the clouds had lifted sufficiently to permit of a short trial trip. Our design was to fly to a coalmine farther to the north-west, in Advent Bay, belonging to the Store Norske Mining Company, in order to thank the local representatives for kindly allowing us the use of the hut in which we were lodging—for it had been taken over by the Store Norske Company from the Anker Company. Neumann acted as pilot; and Löwe, who was to study the working of the compass, was to occupy the second seat in the pilot's compartment. In the cabin were Widding Danielsen (the chief of the wireless station) and myself. In a few minutes we had crossed the Green Harbour mining settlement and the low-lying Cape Heer, to reach the open Ice Fjord, but it was too hazy to distinguish the northern shore. Now we headed north-eastward for Advent Cape, 30 kilometres (19 miles) away, at the entrance to Advent Bay. The southern shore was formed by a monotonous succession of rounded plateaus, whose primitive connexions could be admirably discerned from the height at which we were flying. The upper stratum consisted of a reddish, much-weathered tertiary sandstone. Beneath this, at an altitude of a little over 600 feet, were plainly to be seen, outcropping here and there, two almost horizontal coal-seams about three

feet in thickness. Aided by the west wind, in twenty minutes we reached the Norwegian mine, and came down on the water not far from the quay, opposite a sandy beach. On to this, with the aid of the astonished miners, our seaplane was soon drawn up.

The surroundings of Advent Bay are gloomy and bleak. It is a dead world of rocky debris and sandstone cliffs, the only touch of life in the scene being furnished by a small, now considerably retracted glacier a good way up one of the lateral ravines. As a rule, Spitzbergen landscapes are charming, but here we have an exception. All the more reason, then, had I for interesting myself in the details of the mining enterprise. The war was probably the main stimulus to the exploitation of this mine, for Norway needed coal, and here was a welcome source of supply. It is mined from an outcrop at a height of 280 metres (920 feet), and is carried down to the quay by a funicular railway. From one of the galleries in the hillside, smoke issues unceasingly. Here the seam has been on fire for two years.

The members of the managerial staff invited us to supper, and we spent a most agreeable evening. What a contrast to the arctic wilderness without was the supper room, with fine Norwegian oil-paintings hanging on the walls. An excellent supper, too, with beer and wine and

all sorts of delicacies. We were loath to quit this hospitable abode! But at 9 in the evening we reentered our flying machine, and, having made a farewell circuit of the settlement at a height of about 300 feet, we directed our course south-westward and were speedily alone once more in the great silence of the arctic. We reached our home in Green Harbour at 9.40.

A Trial Trip.—July 6th was the first fine, calm day since our arrival in Spitzbergen. It opened with a flood of golden sunshine. Now we could enjoy the whole panorama visible from the hut. Undisturbed by grey cloud-wreaths, the eye could range across the tranquil fjord, over green-shimmering glaciers, to the distant mountains. Immediately after getting up, I asked to have the machine made ready for flight, charged the magazines of the cameras, and installed all necessary apparatus in the spacious cabin.

The aim of to-day's flight was to make an extensive reconnaissance northward and north-eastward, in order to take photographs of the lateral fjords in Ice Fjord (which are most interesting and typical), and in order to study the possibilities of landing upon the glaciers and the bay ice.

Neumann and I set out at 10.30. The sea was like a millpond, the engine was in perfect order, and we rose without a hitch. To-day,

31. Newton Peaks, in the Chydenius Mountains, the highest summits in Spitzbergen, seen from a height of seventeen hundred metres, looking westward.

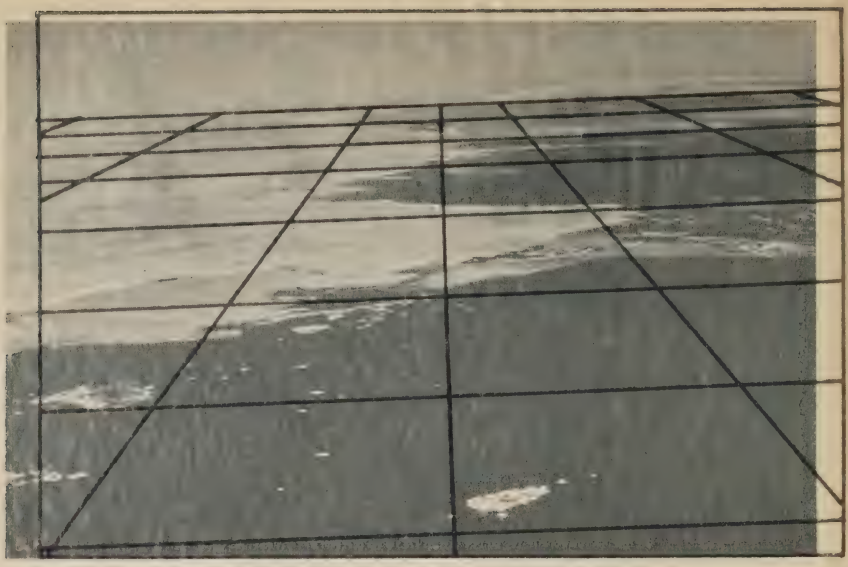
32. Mount Dauman and Mount Lex, in the Alkhorn Group, seen from a height of nine hundred metres, looking north-westward. In the background, a cloud stratum drifting westward across the Foreland Sound and Prince Charles Foreland.

33. North East Land, seen from a height of two thousand metres, looking southward. The land is covered with snow and ice, the edge of this ice-cap having a thickness of about ten metres. Rocky islets in the foreground.
Ten-kilometre squares.

34. The North-Western Corner of North East Land, from a height of two thousand metres; looking north-eastward.
Ten-kilometre squares.

moreover, the load was light, for, since we designed to make an extensive circuit, we must husband our fuel, and must open the throttle as narrowly as possible. In five minutes, at a height of 800 metres (2,820 feet), we had crossed Green Harbour mining settlement, where from this altitude the wooden huts looked like a child's toys. (See Fig. 8.) I could see quite distinctly the black mouths of the galleries leading into the coal-seam, which is about three feet thick, and extends along behind the wireless station at a height of approximately 150 metres (500 feet) above sea-level. This is the uppermost stratum of coal, and it runs in the tertiary sandstone far towards the north-east and south-east.

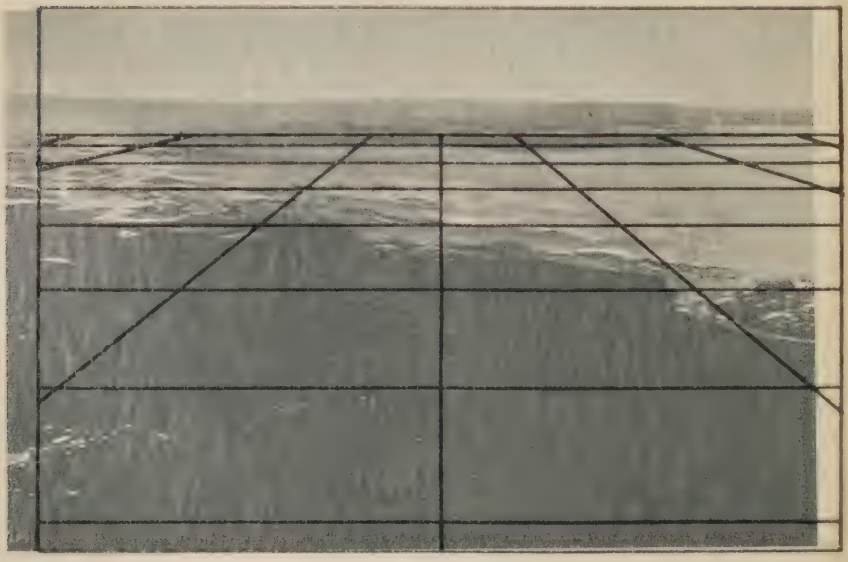
As we gradually rose higher above the flat and monotonous surface of Cairn Gunnar, new and higher plateaus came into sight, all forming the same kind of landscape. From the lofty watch-tower of an airplane, the observer receives a most striking demonstration of the general law that in like geological areas the processes of weathering and denudation give rise to similar landscapes. Little snow was lying here, although the land along the westernmost part of the fjord was still thickly covered. On these rounded hills, obviously, most of the winter snowfall fails to secure permanent lodgment: the westerly gales drive the snow down into the fjord. Only where the mountains are steep and form many



33. North East Land, seen from a height of two thousand metres, looking southward. The land is covered with snow and ice, the edge of this ice-cap having a thickness of about ten metres. Rocky islets in the foreground.

Ten-kilometre squares.

Ten-kilometre squares.



34. The North-Western Corner of North East Land, from a height of two thousand metres; looking north-eastward.

Ten-kilometre squares

moreover, the load was light, for, since we designed to make an extensive circuit, we must husband our fuel, and must open the throttle as narrowly as possible. In five minutes, at a height of 800 metres (2,820 feet), we had crossed Green Harbour mining settlement, where from this altitude the wooden huts looked like a child's toys. (See Fig. 8.) I could see quite distinctly the black mouths of the galleries leading into the coal-seam, which is about three feet thick, and extends along behind the wireless station at a height of approximately 150 metres (500 feet) above sea-level. This is the uppermost stratum of coal, and it runs in the tertiary sandstone far towards the north-east and south-east.

As we gradually rose higher above the flat and monotonous surface of Cairn Gunnar, new and higher plateaus came into sight, all forming the same kind of landscape. From the lofty watch-tower of an airplane, the observer receives a most striking demonstration of the general law that in like geological areas the processes of weathering and denudation give rise to similar landscapes. Little snow was lying here, although the land along the westernmost part of the fjord was still thickly covered. On these rounded hills, obviously, most of the winter snowfall fails to secure permanent lodgment ; the westerly gales drive the snow down into the fjord. Only where the mountains are steep and form many

sheltered nooks does the snow lodge, to become compacted ultimately into an ice-cap and form glaciers. In Spitzbergen, generally speaking, the snows attain a small depth only, and that is why so much of the land area was snow-free thus early in the summer.

Now we had reached the western extremity of Ice Fjord, which is 15 kilometres (10 miles) wide. Farther to the west was the polar sea, vanishing into a wall of fog, but the eastward view, up the fjord, was magnificent. Rising sheer out of the sea was the trinity of inaccessible rocky peaks : Alkhorn, 610 metres (2,000 feet) ; Mount Protector, 851 metres (2,825 feet) ; and Mount Daumann, 876 metres (2,876 feet). These are shown in Fig. 9. Farther up the main fjord were the lateral fjords and glacier after glacier, alternating with the sharply-cut intervening serrated ridges.

Crossing the Vermeland Chain, we flew over the Esmark Glacier, whose lower end breaks away as glistening icebergs into the dark green waters of the fjord, and soared above the Erdmann Tundra, 10 kilometres (6 miles) wide. (See Fig. 10.) All the secrets of King Oscar the Second Land were now revealed to our gaze. Down from the Trollheim Plateau into North Fjord there flow huge but shallow rivers of ice, having a width ranging from 5 to 8 kilometres (3 to 5 miles) and a length ranging from 20 to 40 kilometres (12 to 25 miles).

In half an hour's flight, though economising fuel to the utmost, we had reached a height of 1,200 metres (4,000 feet). I signed to Neumann to make a gentle turn towards the right, and now by degrees a marvellous picture unfolded itself to my wondering eyes, a view of Ice Fjord with its dark bluish-green waters, its encircling mountains and glaciers, and its bays in which for the most part the ice was still unbroken. After a busy time with the cinema apparatus and the ordinary cameras, I directed our course north-eastward into Dickson Bay, likewise ice-bound. The sides are formed by steep, much weathered, reddish-brown rocky hills, whose gorges, deeply eroded (presumably by glacial action), give them a peculiar and somewhat sinister aspect. Obviously these hills are the vestiges of a sometime plateau. (See Fig. 16.)

From our altitude of 2,000 metres (6,560 feet) we had a most extensive prospect. To the south I could instantly recognise the characteristic hills of Green Harbour, and far beyond these there stretched an endless array of mountain tops, like wave upon wave of a tossing and tumultuous sea. Northward the clouds had massed, and only here and there did some of the highest summits of the Chydenius Mountains, wearing ice-caps, project above the dazzling cloud stratum. Farther flight to the north being thus barred, we turned southward, and volplaned

down a gentle slope to a height of 80 metres (265 feet). From this slight elevation I could easily make out the structure of the fjord ice, which is quite superficial, being formed by local freezing in the course of the four months of the arctic night. It has a moderately rough and granular surface, one on which it would be practicable to descend in an airplane fitted with runners, though not without risk of injuring the undercarriage. Safer for landing seemed to me the surface of the glacier, along whose face, 30 metres (100 feet) in height, we now flew in order to take a series of cinema pictures. The Spitzbergen glaciers are as a rule much tamer and smoother than those of the Alps. In their upper parts, where there are no crevasses, they would serve excellently for landing and starting stages.

Now we moved swiftly over the Boheman Tundra. Its general tint, where the earth and the moss were exposed, was dark brown; but patches of snow still lingered. In its present state of thaw, the spongy, superficial layers had a downward flowing movement over the frozen depths, the flow being clearly indicated by the fissure-lines on the surface.

From Cape Boheman we steered straight across Ice Fjord, here 30 kilometres (18 miles) wide, to Cape Heer, and on into Green Harbour, making a good descent, and completing our circuit at 12.42.

35. Norwegian Islands to the right, Fowl Island to the left. In the background, Amsterdam Island.
Seen from a height of fifteen hundred metres, looking south-westward.

36. In the foreground, Fowl Island.
In the middle distance, Amsterdam Island, towards which from the west is drifting the mist forming over the coastal current.
Behind this, the open sea, free from mist.

Advantages and Drawbacks of Arctic Aviation.—In this fairly extended flight I had been particularly impressed by the stillness and clearness of the air. Whereas in the Alps, during summer ascents, the machine is continually being tossed about by the wind, here its flight was entirely untroubled, even when we were flying close to the mountain crests. Owing to the fact that there is so little difference of temperature between the "day" and the "night," owing to the persistent warming of the surface by the sun throughout the twenty-four hours, the dreaded vertical winds of our Alpine valley are unknown in Spitzbergen. This makes aviation extremely pleasurable in the far north. The airplane moves steadily forward on its appointed course. The pilot has little trouble with the steering, and can give himself up to the enjoyment of the peculiar charms of arctic scenery. Were it only possible to have perfect confidence in the engine, such a flight as the one I have just described could be regarded as a mere pleasure-trip. But suppose that engine trouble had forced a landing, what then? We might, distant only a quarter of an hour by the aerial route from Green Harbour, have had to descend upon the farther side of Ice Fjord. Then there would have been nothing for it but to undertake a 150 miles march, across glaciers, over screes, and (worst of all) through wide tundras, where the feet sink above the

ankle in swampy ground. I think it would have taken a vigorous pedestrian a week or ten days, perhaps more, to make his way round Ice Fjord back to Green Harbour.

Happily one does not, as a rule, ponder these alarming possibilities until the enterprise has been successfully accomplished. We had good reason to be satisfied with our little tour of inspection. Everything augured well for the future.

Midnight Sunshine and Wintry Summer.—We spent the rest of that day, and part of the night that followed it—the first, never-to-be-forgotten, fine, sunlit night in the far north—in front of our hut high above the wireless station. Behind us was the red-brown eminence of Cairn Olaf, glowing in the rays of the midnight sun. Its lure was irresistible, and at 11 o'clock Hammer and I started upon this little ascent. Everywhere in the shade the thawed surface of the snow patches had refrozen, and it was across these slides and up slippery screes that we had to reach the summit. In places the runnels had cut deep fissures, and much of the rocky footing was perilously loose. But, triumphing over these little difficulties, I was at the top by midnight. There I had to wait a long time for Hammer, for he was still far below, toiling up a steep scree, dripping with sweat and breathing maledictions. The air was perfectly still, and

in the sun it was quite hot, so I stripped to the buff and had a sunbath while enjoying the view. Westward was the mouth of the fjord, with a glimpse of the open sea; northward, the sun, shining down upon a cloud-sheet spread wide over the interior of King Oscar the Second Land. In front of the clouds were the nearer mountain tops, silhouetted in dark violet against the golden sheen; between them, in the valleys, the smooth glaciers gleamed with a yellower gold. North-westward was Prince Charles Foreland, its ice-capped ridges defiantly towering above the Foreland Sound; here, too, was a faery realm of gold. A strange, a contradictory world. I was lapped in the warm caress of summer, and yet, wherever my glance fell, Nature seemed petrified by the chill touch of King Frost.

A Foggy Day.—I awoke at noon, from a long and sound sleep, to find that the weather had become chilly and disagreeable, and that there was a thick fog. The Norwegian auxiliary cruiser "Farm," which had been for several weeks in the waters to the northward of Spitzbergen, had come into the harbour and had anchored just in front of the wireless station; the Tromsö whaler "Eisbjörn," chartered by a Hamburg merchant for a bear-hunt, had also arrived. First we paid our respects to the

"Farm," and were hospitably entertained. Captains Hermansen and Hagerup gave us valuable information anent ice conditions off the north coast of the islands, and advised us as to our intended overland flight. Then we rowed across to the "Eisbjörn," and the fortunate bear-hunter showed us sixteen fine bearskins, the fruit of his skill with the rifle.

By now the fog was lifting, and the sunlight was showing on the western sea. The mist-wreaths drifted away to the southward, and the blue vault of heaven was again visible above the white peaks.

Second Trial Trip.—At seven that evening, an hour when in Switzerland no airman would think of starting upon a long overland flight, Neumann, Hammer, and I set off with enough fuel to last us four hours. My main purpose this time was to scrutinise the region between Ice Fjord and Foreland Sound, the glacier-laden area of the Holtedahl Plateau and King Oscar the Second Land, so that in the event of a forced landing during some subsequent flight, and a need for a return on skis, I should have some idea of the best route. By 7.30 we had crossed Ice Fjord and were flying over the Svea Glacier, about 40 kilometres (25 miles) long, up the so-called King's Way to the north-west. In front of us and to the west, large areas were still enwrapped

in cloud, through which fantastic pinnacles and long spines of rocky eminences projected. Most striking was the contrast between the hard crystalline rock of the Hecla Hook formation (which weathers into pointed peaks and knife-edged ridges—see Fig. 21), to the westward, and the red sandstone strata of the younger permian and carboniferous formations (whose denudation gives rise to gentler hill-shapes—see Fig. 25), to the eastward. Especially conspicuous was this contrast to-day, when, to the westward, the dark contours of the hills were in such sharp relief against the dazzling whiteness of the sunlit cloud-stratum. The lovely garland-forms of the Mount Holta Range (see Fig. 21) reminded me strongly of the bold peaks of the Finsteraarhorn Chain in the Bernese Oberland; and the same remark applies to the more distant mountains of Prince Charles Foreland, whose loftiest peak, Mount Monaco, is 1,080 metres (3,540 feet) in height. (See Fig. 15.)

From the cabin I could get only lateral views, the pre-and-aft landscape being hidden. I therefore had to make Neumann guide the plane on a sinuous flight, so that I could obtain photographs and cinematographs in all directions. Thereby Hammer, who was sitting beside Neumann upon the second seat in the pilot's compartment, had his sense of direction much confused, and tried to orient himself by repeated

glances at the compass. But this instrument was in the same state of confusion as himself. After one of our sweeping curves, the needle took a long time to settle down; and even then it was inclined to err, as I was able to ascertain with the aid of the sun and the chronometer. The curves in the line of flight that inevitably result from the use of the foot-steerer, and are accentuated by accommodation of the flight to gusts of wind, give rise to centrifugal stresses which necessarily affect the compass. Even in comparatively low latitudes these deviations are considerable. In the far north, where the vertical intensity of terrestrial magnetism is many times greater than the horizontal intensity, the compass becomes practically useless for aerial navigation. But to-day, flying in the sunlight and far above the clouds, I was happily independent of its aid!

We were at an altitude of 2,000 metres (6,560 feet), and it was 8.8 p.m. by Central European time. The map showed that we were flying along the meridian of 13° east. Disregarding certain minutiae, the sun souths over this meridian at 12.8 by Central European time, and continues to move clockwise one degree every four minutes. At 6.8 p.m. it is due west. It was easy enough to calculate that now, at 8.8, the north must be $4 \times 15 = 60°$ to the right of the present bearing of the sun. But away with navigation!

37. Brögger Peninsula, seen from a height of seventeen hundred metres. In the right background, Quade Hook. In the left background, Prince Charles Foreland. In the foreground, the Three Crowns Glacier. To the right, the Löven Islands. There is fog above the cold current on the west coast.

38. Lomme Bay, from the south, seen from a height of fifteen hundred metres.

39. Lomme Bay from the south-east, seen from a height of fifteen hundred metres.

40. Lomme Bay from the north-east, seen from a height of fifteen hundred metres.

Away with ciphering and the measurement of angles! The simpler the method of orientiation, the better for the airman, and the more easily will he steer his course through unknown regions.

To-day, when the weather was so clear and the visibility so splendid, I found it child's play to determine my bearings, even after a sinuous flight for the taking of photographs, during which my attention had been wholly concentrated upon that engrossing occupation. A glance into the distance sufficed to tell me where we were. All around were the features with which I was growing familiar: my acquaintances at the entrance to Ice Fjord; dead astern, the characteristic forms of the hills at Green Harbour, some of which I had already climbed; and range upon range of hills, like the waves in a stormy sea.

Our engine had been working admirably, so we ventured to plane down in order to skim over the summits of the Three Crowns, beautiful mountains, of which I wished to secure pictures for cinematographic reproduction. Then, after flying for more than an hour over the King's Glacier, and the Holtedahl and Lorenskjöld Plateaus, we turned southward. From time to time, through the mist-wreaths, we caught sight of the greenish-blue open waters of the Foreland Sound along the west coast. (See Fig. 15.) Now we were crossing the ice-streams of the

Osborn and Konow Glaciers, which debouched into the still-frozen St. John's Bay. (See Fig. 17.) Very remarkable is the way in which the narrow mountain spines, sculptured by the mightier glaciers of earlier days, project out of the broad ice-filled valleys.

Rocky crests which have been here and there almost entirely eroded, bear witness to the more powerful glaciation of the ice-age. In conjunction with the hummocky landscapes of certain other parts of Spitzbergen, they show that the islands were at one time hidden, or nearly so, beneath a huge ice-sheet. (See Fig. 17.) The glaciers over which we were now flying had numerous runnels and pools on their upper surface. (See Fig. 42.) The only glacier to compare with this in the Alps is the Concordia Platz of the great Aletsch Glacier, though there the phenomenon is much less marked. The surface of these Spitzbergen glaciers is, in places, beautifully smooth. Our seaplane, though fitted with floats and not with runners, could land and start safely enough. The snow had become regelated and granulated, and would bear very nicely.

Our homeward flight took us across the ice-covered chain of Mount Lex (see Fig. 32), and over the narrowest part of Ice Fjord. We returned to our starting-point at 9.45 p.m., after a flight lasting two-and-three-quarter hours.

The Main Flight.—After these successful trial trips, I felt that I had learned enough of the lie of the country and of local meteorological conditions to venture (now that the weather prospects were favourable) upon an extended flight, across the central and highest peaks of Spitzbergen, northward to North East Land and the edge of the ice-pack.

We prepared therefore, for our first lengthy excursion into the unknown arctic. Holbein, the mechanic, a brisk young fellow of barely twenty, overhauled the engine with the utmost care, and filled the fuel and lubrication tanks.

Having recharged my multifarious photographic apparatus, I returned to our ideally situated hut. It was now midnight. A new week was beginning. I sat on a bench before the hut, enjoying the gentle warmth of the midnight sun and the peaceful stillness after the thunder of our flight. Sleep was out of the question on this brilliantly lit arctic night. I thought over the intended flight, which was to take us across unexplored wastes of ice and snow. After careful consideration I decided to fly from Ice Fjord over the Chydenius Mountains, whose culminating peak is Newton with a height of 1,730 metres (5,618 feet), across New Friesland, a mountainous region about 80 kilometres (50 miles) wide, to Hinlopen Strait, which was still ice-bound. The return journey

would be along the northern and western coasts of Spitzbergen. On my visit to the " Farm " I had learned from Captains Hermansen and Hagerup that there were some ships (whalers or sealers) in Wyde Bay and along the edge of the ice-pack. This news was somewhat reassuring in view of the possibility of a forced landing during a flight which was to extend for more than 500 miles through an uninhabited and frozen land. It was a comfort to feel that, in the event of engine trouble, we could direct our course towards one or other of these vessels.

The morning of Sunday, July 8th, was beautiful. The blue waters of the fjord were perfectly calm, so still that they mirrored the white splendours of the icebergs. Nothing troubled the Sabbath quietude beyond the occasional passing of a flight of eider-ducks. I could fancy myself in the High Alps, beside one of our Swiss lakes, about to start on a mountaineering expedition. The Alkhorn, guardian of the secrets of Ice Fjord, was as bold in outline as any of the Wetterhorns in the Bernese Oberland.

For the last time Neumann overhauled his aluminium bird, while I was busied upon stocking the plane with food sufficient for three weeks, firearms, skis, sleeping sacks, and all necessary apparatus. The photographic and cinematographic equipment—a heavy item—must not be forgotten ! On the chart table over the spare

fuel tank I fixed the maps. Beside them were chronometers, a pair of compasses, and other instruments of precision, including a quadrant in case we should have to return on foot. Thus provided, I hoped that, even should we be forced to abandon the airplane, we should be able to make our way safely within a few weeks to the nearest human habitation. My chief concern here was for Neumann, who had never worn snowshoes, and was by no means in good training!

At length all was in order, and at 11.40 a.m. we started. The plane, "Icebird D. 260," was heavily laden, and rose from the water with some difficulty. The engine was not developing its full power, and declined to work with Magneto I., even when the throttle was widely opened. Flying low, we passed the hutments of the Dutch coalmine, and then turned north-eastward across the flat, swampy tundra of Cape Heer. Ice Fjord, 90 kilometres (56 miles) in length, was now displayed in all its titanic proportions. Glaciers flow down into it from all directions, but especially from the north, the ice-streams being confined between rocky crests. Northward of the fjord lies a sea of pinnacles and ridges, now sharply outlined against the horizon—a view as manifold and mighty as any to be seen in the Alps. The sky was cloudless. To the southward, too, snowpeak towered behind snowpeak. The heavens were of the rich blue which is charac-

teristic of Italian skies, and the atmosphere was so clear that the prospect seemed illimitable. Under such conditions, aerial navigation offers no difficulties, and the airman looks forward with unalloyed pleasure to the coming hours.

But what has gone wrong with the engine? Whenever Neumann tries to open the throttle a few more notches, in order to rise more quickly, there are loud explosions, and then the motor stops. We exchange gesticulations. I write a message to the effect that, if Neumann thinks it expedient, we can return to Green Harbour for an overhaul. But the pilot waves forward. He throttles down so as to allow the minimum of petrol requisite for horizontal flight, and carries on, trusting in his luck. For my part, I have no fault to find with his venturesome decision. I would much rather forge ahead, for who can tell how long this glorious weather will last? Changes of weather come suddenly in Spitzbergen. Now, to seaward, the clouds lying on the water seem no more than a gleaming golden band in the far distance. At any moment a shift of wind to the west may bring them rolling down upon us! But the air is tranquil, and very slowly the plane climbs as it wings northward through an air that "carries" well. More and ever more magnificent are the outlooks over the mountains and the glaciers of Spitzbergen.

In Billen Bay, which we left at 12.40 p.m.,

41. Broad Bay and the hills of the north-west coast, seen from the east, from a height of fifteen hundred metres. Rightwards extends the open Polar Sea, covered with drift ice.

42. The Eidem Glacier, seen from a height of twelve hundred metres. Pools and deeply indented streams having a width ranging from five to ten metres are seen on the surface of the glacier. Note the shapes of the hills. Above the clouds from the centre leftwards, the Trollheim Chain and the Alkhorn Chain.

I had plenty of time to study and touch up my map. This was the limit of the observations made by the Norwegian expedition of 1909–10, under the leadership of the cartographer Isachsen. For instance, the little Goose Island over which we were now flying was not accurately charted ; and I found it possible to amend the mapped outlines of Gypsum Bay and the Gypsum Quarter. I had to use my cameras, to sketch, and to take notes, by turns, this rapid succession of occupations being facilitated by the construction of the roomy cabin, with its two lateral windows and a third window to the front, towards the pilot's seat. It would have taken me days and months of toil to achieve by the old methods of exploration what I could effect here at ease in as many seconds or minutes. On either side of Billen Fjord, the glaciers were small and few in number ; but they became much larger and more numerous as our flight took us northward across the granite ranges of the Chydenius Mountains. The innermost end of Klaas Billen Bay (it was now open water) is formed by the face of the Nordenskiöld Glacier, which runs down as a wide icestream from the mountains in the north-east. (See Fig. 20.)

I signed to Neumann to follow this route. On the northern horizon the way (at our present level) was barred by the dark granite wall of the Chydenius Mountains. Over the " port bow " of the airboat could be seen the long and narrow

fjord known as Wyde Bay, 150 kilometres (94 miles) in length ; and, at the far end, the dark, bluish-green waters of the Polar Sea. But what did that white wall of fog betoken ? Attentively I watched it, ready for a change of route should the cloud barrier hinder our advance towards the north coast.

Great concentration was now requisite. We had only attained an altitude of 1,700 metres (5,520 feet), and the mountains in front were much higher than that. Whenever Neumann opened the throttle a little wider, the engine stopped, just as it had done half an hour before. Since we could not clear the summits, there was nothing for it but to fly between them, at the risk of being stormed-tossed by the fierce gusts of such regions. But this gave a fine opportunity for cinema work, as we skimmed over deep chasms, and whizzed past shimmering ice-cliffs, curving hither and thither in order to get the utmost possible amount of movement and variety into these unique pictures of the mountain tops of Spitzbergen. Neumann played his part with admirable bravura. A tap on his left shoulder with my ski-ing staff signified that he was to wheel to the left, and to continue bearing to the left until a tap upon the head gave the signal for a straighforward course. Other signs had been prearranged for abrupter turns, and for ascent or descent, as circumstances might demand.

In our trial flights we had drilled ourselves in the use of this code of signals, for such drill is essential to good observation and to satisfactory airplane photography, if results are to be secured with a minimum expenditure of time and energy. After a rapid study of the map and a determination of our course by the sun, I must again and again seize one or other camera, and set to work taking photographs. Each view had forthwith to be numbered, and its place noted in the map, with a record of the hour and of the bearing of the camera. Then, from time to time, I would give Neumann the signal for sinuous flight, while I turned the winch of my cinematic camera.

Thus, in a seaplane be it noted, we soared for half an hour among the peaks of the highest range in Spitzbergen. (See Figs. 11, 12, 29, and 31.) Enthralled by the beauties of this splendid scenery, and both of us hard at work, we had no time to worry about possible dangers. As soon as I had taken all the photographs I wanted, I signed for a continuation of our flight towards the north-east. The Chydenius Mountains are of gneiss and granite, weathering into huge masses covered with an ice-sheet ranging from 60 to 120 feet or more in thickness; and into precipitous knife-edged ridges with steep, eroding glaciers on either hand. From this formidable country, we now passed to a huge, ice-covered plateau, upon which a landing would have been

perfectly feasible. Directly in front of us, various glaciers with central and lateral moraines were flowing downwards into Lomme Bay ; while due northward the ice-sheet spread like a shroud, sloping gently downwards on either side, and extending for 90 kilometres (56 miles) to the farthest point of New Friesland. (See Figs. 38, 39, and 40.)

At 2 p.m. we passed the inner basin of Lomme Bay, ice-free here and there, where the streams running down from the glaciers had thawed the bay ice. The colour of the landscape beneath ranged from pure blue to rich green. On both sides of the bay, the snows had for the most part melted. Even from our present height the characteristic features of a " hummocky " country were discernible, showing that in this as in so many other parts of Spitzbergen there must in former days have been a much thicker and more extensive covering of ice. (See Fig. 40.)

After a flight which had now lasted for two-and-a-half hours, we had at length reached the desired height of 2,000 metres (6,560 feet). Northward and north-eastward, across the icebound Hinlopen Strait (here about 10 miles wide), I could see for an immense distance into the enigmatic North East Land, whose inland ice pours down in huge streams into the surrounding seas. According to the map, there is here an ice-wall more than 450 metres (1,480 feet) high, but I could see

nothing of it. The ice seemed to stretch inland unbroken, with gentle undulations.

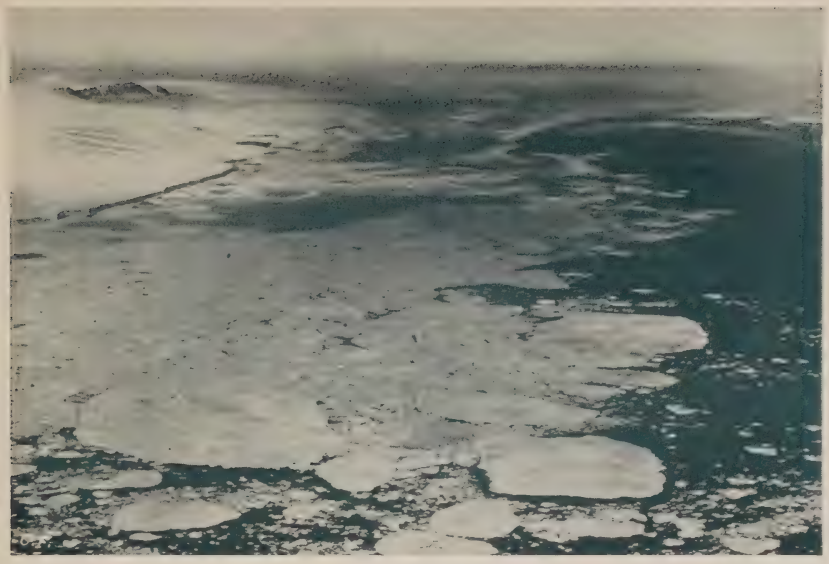
A strong north wind was now blowing, and impeded our progress. If we diverged eastward or westward to take photographs, we were at once driven to leeward.

Owing to the tempering influence of the Gulf Stream, and thanks to the vigour of the summer sunshine, the ice had largely vanished from the sea to the north of Hinlopen Strait. The strait itself, however, to the south of Wahlenberg Bay, was still frozen over, and filled with pack ice. (See Figs. 43 to 46.) Beneath us lay the tumultuous ice-field over which the polar expeditions of old days had to struggle. With dogs and sledges they toilsomely made their way step by step, on short rations, when every pound's weight meant so much more labour; and often the drift of the ice in the polar basin was all the time neutralising their progress, rendering futile their almost superhuman exertions. A day's march under such conditions (leaving the aforesaid drift unconsidered) would range from half a dozen to a dozen miles. But we, without the least effort, were able to fly northward at a speed of nearly 90 miles per hour; with the further advantage that, from this great height, we could pick our course without the slightest difficulty.

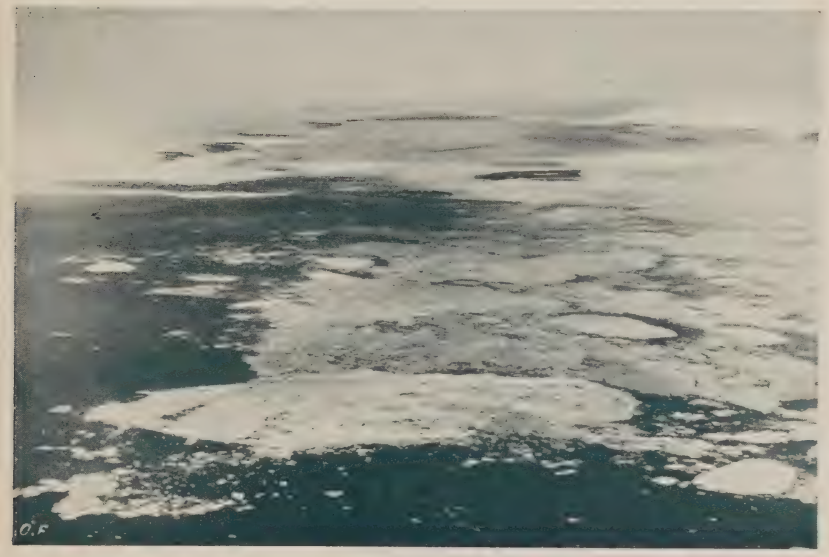
At the first glance, the pack ice looked perfectly smooth; but on closer examination the shadows

of the very irregularly disposed ice-crests and ice-walls could be made out. Large ice-floes, ranging in width from 1,500 to 2,000 feet, were abundant (see Fig. 43). These had a smoother surface, and presumably consisted of younger ice, which had not been subjected to so much pressure. Still, I do not think that a plane, even though furnished with runners, could land on or start from these without too much risk of mishap. In this region, the only suitable landing ground would have been the land on either side of Hinlopen Strait, covered with flat inland ice.

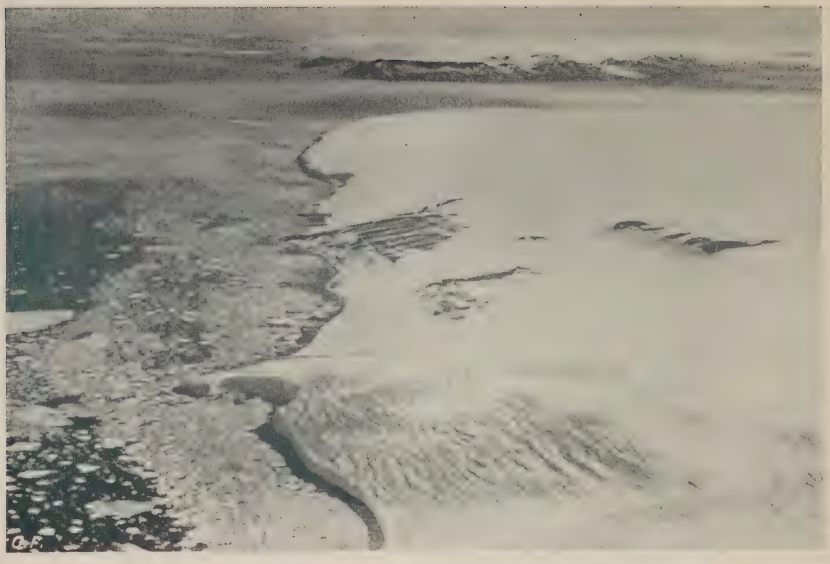
From the reports of Stefansson, Peary, and various whaling captains, we had learned that the surface of the pack ice is at its worst along a strip round the coast ranging from 20 to 50 miles in width, where the pressure of the drifting ice piles up ice-walls and pinnacles which may be as much as 50 feet high. Farther seaward, open channels (lanes or leads) often form in the ice-sheet, even in winter. After a few days, these get frozen over, to a thickness of about a foot. This young ice is quite smooth, and here the conditions for landing from the air are obviously favourable. But the omens for a restart may be less propitious! Perhaps for many days in succession, or even for weeks, the arctic fog might make the resumption of flight impossible. During this period, the floe which had been selected for a landing might easily break up. Maybe in the



43. Pack Ice in Hinlopen Strait, seen from a height of two thousand metres. To the left, the north-east coast of New Friesland, covered with inland ice, which breaks steeply into the water. To the right, an open channel.



44. Pack Ice in Hinlopen Strait, seen from a height of two thousand metres. Snow ridges and leads in the opening pack ice.



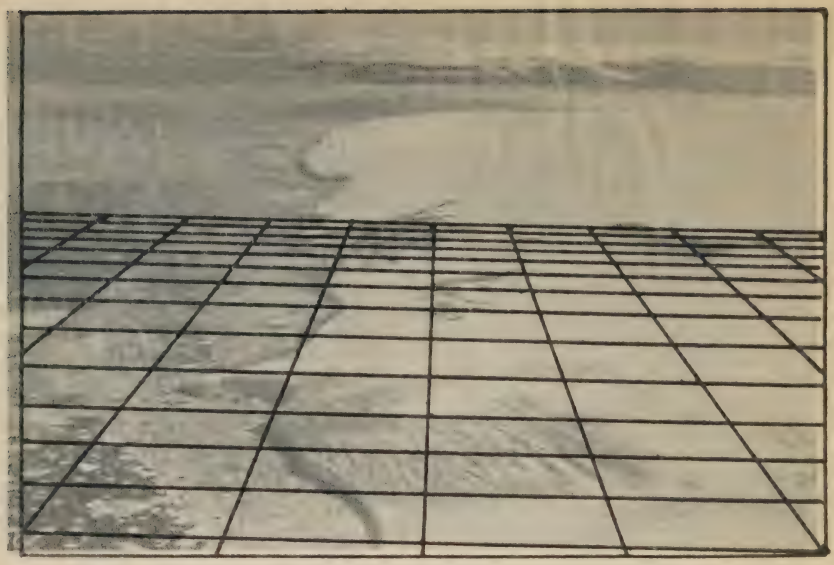
45. North Eastern coast of Western Spitzbergen, seen from a height of two thousand and two hundred metres. Glacier face fifty metres in height. Two-kilometre squares.

46. Pack Ice in Hinlopen Strait, seen from a height of two thousand metres. Two-kilometre squares.

future, airplanes for arctic aviation will be fitted with an undercarriage enabling them to land and start equally well from ice and from water.

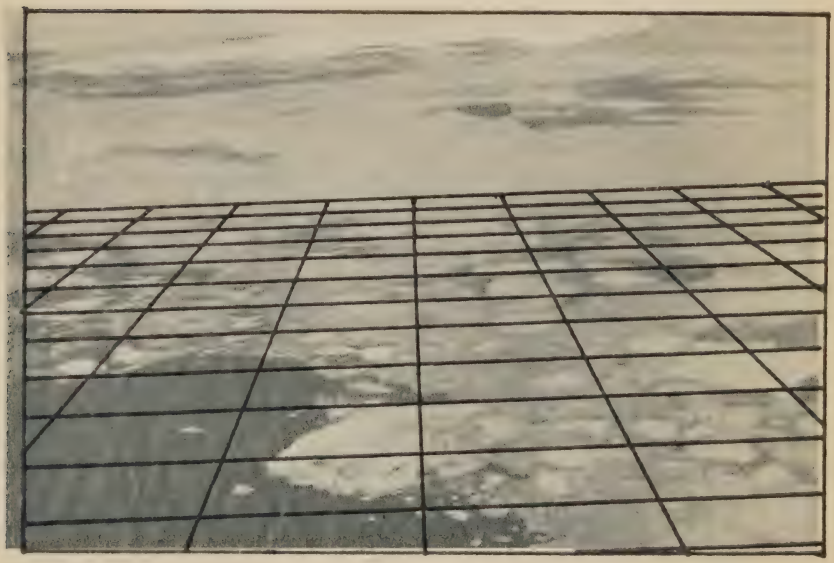
To the north-east was now visible a snow-capped peak towering over the flat inland ice of North East Land, and pointing out the way towards North Cape, 80° 50′ N. and 28° E. In this direction the air was perfectly clear, and we could easily have soared northward beyond the land to the eighty-first or even the eighty-second parallel—if only our engine had been behaving better. But misfires were becoming so frequent that a complete stoppage seemed likely enough from moment to moment. Reluctantly, therefore, I had to renounce the idea of continuing our flight across North East Land; for had we been forced to land there, and been unable to restart the plane, it was highly improbable that we should have been able to escape on foot. Our equipment was too primitive for a long land journey in the arctic.

Neumann, a thoroughly competent mechanic as well as a pilot, thought, as I did, that the cause of the bad functioning of the engine must be something wrong with the sparking plugs. He wanted to descend upon an area of open water, where he could deal with the matter with such tools as we had brought along. I refused, however, to risk a landing in Hinlopen Strait, my main objection being a fear of injury to the floats.



45. North Eastern coast of Western Spitzbergen, seen from a height of two thousand and two hundred metres. Glacier face fifty metres in height. Two-kilometre squares.

Two Kilometre Squares



46. Pack Ice in Hinlopen Strait, seen from a height of two thousand metres. Two-kilometre squares.

future, airplanes for arctic aviation will be fitted with an undercarriage enabling them to land and start equally well from ice and from water.

To the north-east was now visible a snow-capped peak towering over the flat inland ice of North East Land, and pointing out the way towards North Cape, 80° 50′ N. and 20° E. In this direction the air was perfectly clear, and we could easily have soared northward beyond the land to the eighty-first or even the eighty-second parallel—if only our engine had been behaving better. But misfires were becoming so frequent that a complete stoppage seemed likely enough from moment to moment. Reluctantly, therefore, I had to renounce the idea of continuing our flight across North East Land; for had we been forced to land there, and been unable to restart the plane, it was highly inprobable that we should have been able to escape on foot. Our equipment was too primitive for a long land journey in the arctic.

Neumann, a thoroughly competent mechanic as well as a pilot, thought, as I did, that the cause of the bad functioning of the engine must be something wrong with the sparking-plugs. He wanted to descend upon an area of open water, where we could deal with the matter with such tools as we had brought along. I refused, however, to risk a landing in Hinlopen Strait, my main objection being a fear of injury to the floats.

I decided to skirt the northern and western coasts of the main island as far as King's Bay, and then to fly straight across King Oscar the Second Land to Green Harbour—flying always with a partially closed throttle. What we learned from an examination of the engine after we reached home, showed that this decision had been a wise one. Magneto I., which has to supply the high-tension current for the ignition of the mixtures in the cylinders through series I. of plugs, was quite out of order. That was the explanation of the tricky way in which our engine behaved. When the throttle was widely opened, Magneto II. was not able to effect the complete ignition and combustion of the compressed charges of explosive mixture in the cylinders; it could only do this when the engine was working at half speed. Had we landed, we should have been unable to remedy this trouble, for we had no spare magneto to replace the defective Magneto I. With only Magneto II. in working order, we should have been unable to rise from the water. A seaplane rises less easily than an ordinary airplane, for the force of cohesion between the floats and the water has to be overcome. For this, the maximum reserve energy of the motor has to be brought into play.

Our only resource would have been to skim the surface of the water like a motor boat, making our way among the ice-floes, until we reached an

ice-sheet practicable for marching—or, better still, until we reached the land. Thence, being accustomed to glacier work, and an experienced skier, I should have tried to cross the great ice-covered plateau of New Friesland to Wyde Bay. From here it would have been necessary to traverse the mountains and glaciers of King James Land in order to reach the coalmining settlement at King's Bay. As far as my personal safety was concerned, I was free from anxiety. I was sure that I could overcome the dangers of the unknown arctic, for I had been in a tighter place. Three years earlier I had made a forced landing during a fog in the Glarner Alps, coming down above the snow-line at a height of 2,000 metres (6,560 feet). Despite a broken knee, I was able, in thirty-six hours, to reach an inhabited valley. But what about Neumann? He had never been in the mountains, had never seen a glacier before, had had no experience of climbing, and had never worn skis. He was a typical polar bear, big and heavy-footed, far more at home upon the sea than upon the land. "If we had been forced to come down," he said to me afterwards, "I should have stuck to the machine. The cabin would have been a good enough shelter, and there was a fair supply of food. Besides, I could have shot some birds, and perhaps a seal or two. I should have stayed where I was till you brought help!"

Over Whale Island we crossed the eightieth parallel, and here we turned westward. Now, on our left, was the entrance to the still icebound Treurenburg Bay (also known as Sorge Bay), where in 1912 the "Herzog Ernst," carrying the members of the ill-fated Schröder-Stranz expedition, was entangled in the ice. They were ten in number, young Germans who had come hither upon a mission of geographical research. Only three of them ever saw the fatherland again. Although they were amply supplied with food, they took three months to reach the Norwegian mining station in Advent Bay, a distance of only 200 kilometres (125 miles) !

At 3 p.m. we were flying over open water, northward of Grey Hook, the northernmost spur of Andrée Land. From this point Wyde Bay, a long and narrow cleft in the blue hills, runs southward for more than 120 kilometres (75 miles).

From our great altitude I could plainly discern in the extreme distance, far beyond the end of Wyde Bay and a little to the west, the characteristic cretaceous and jurassic formations of the hills surrounding Green Harbour ; and behind these, peak upon peak. Westward the prospect was even wilder and grander. Here, out of the depths of the Polar Sea, there rose, like floating fortresses, deep blue against the gold of the western sky, chains of sharply-cut mountain peaks. Running northward out of these mount-

ains, in parallel series, glacier after glacier, bearing central and lateral moraines, stretched down to the sea. At sight of all this beauty, my anxieties about the homeward flight were forgotten! Never in my Alpine flights had I been able to see to such incredible distances; and never had I seen so glorious a play of colours and lights, richer and purer even than that which the luxuriant vegetation of tropical scenes can furnish.

Although we were now at a height of 2,200 metres (7,200 feet), there was no marked fall in temperature. When we left Green Harbour, the thermometer had stood at 5° C. (41° F.); it was now 1° C. (34° F.). Although there was a strong draught in the cabin, my exertions with the cameras, and with taking observations and making notes, kept me dripping with perspiration.

Northward the outlook was over the sea, with drifting ice-floes here and there, as far as the isolated Moffen Island, ice-beset. Just beyond this, about 50 kilometres (30 miles) away, was a dense sea of fog, rising to a height which I estimated at not more than 300 feet. There was the way to the Pole, which had been the aim of so many explorers, not 700 miles away. We could reach it by airplane in seven or eight hours. A simple matter, if the engine would work satisfactorily, and we could keep above the clouds all the time, so as to guide our course by the sun. And the weather was perfect.

Not a breath of wind, so that flight was perfectly steady. Only when crossing the Chydenius Mountains, and flying very close to the peaks, had we been tossed about by gusts. During the rest of our flight the air conditions had been such as are entirely unknown at this season and at this time of the day in our latitudes—conditions that prevail during summer in the far north because of the equable warmth radiated by the perpetual sun.

All will go well with the arctic aviator if he never needs to land. But what will happen to him if he is compelled to come down upon the ice-field, and cannot rise into the air once more? He has no sledge and no dogs; he is poorly supplied with provisions; and, in this desert of snow and ice, there is no hope of outside help. The stranded airman is most unlikely ever to see home again. His only chance would be to take a leaf out of the Eskimos book, and to live by the chase; that is what Stefansson and his trusty companions were able to do for the first time in the history of polar exploration. But for that, long experience in the Eskimo methods of the chase is requisite, and an adaptation to far northern life such as cannot be acquired in a few weeks.

Until we have airplanes with perfectly trustworthy engines, a flight over wide stretches of the arctic, and in especial a flight from Alaska to

47. Broad Bay, Biscay Hook, Mt. Blanc, and Red Bay from the west, seen from a height of six hundred metres. Drift ice on the sea in the foreground. Sharply serrated mountain ridge (granite) in the background.

48. Cross Bay with Quade Hook, seen from the north, from a height of sixteen hundred metres. In the foreground, the mirrorlike Lilliehook Glacier; in the background, Prince Charles Foreland. On the Diesel Peninsula, splendid glacial ravines, and glacier "dead-ends" (to the right).

Europe, has only a " sporting chance " of success —at any rate until we have a plane with so great a carrying capacity that all the requisites for a long journey on foot across the ice can be taken as part of the equipment. An airship, such as a Zeppelin, would have a better chance, although its inferiority of speed is a disadvantage.

Had it not been for the fog overhanging the ice-field, I might have ventured a flight farther north, in order to study the frequency of smooth patches suitable for the landing and starting of a plane fitted with runners. With nearly closed throttle, our engine was now firing satisfactorily ; and I could reasonably count, in the event of a forced landing, upon coming down within a moderate distance of a whaling ship. But to-day such an expedition would have been futile, owing to the impossibility of seeing the surface of the ice.

At 3.14 p.m. we passed the snow-covered tundra of Reindeer Peninsula. In front of us, Broad Bay (see Figs. 41 and 47) was filled with emerald-green drift-ice. I gave my pilot a sign to plane down close to the water, for I wanted to take some cinema pictures. Suddenly Neumann shouted to me, as I understood : " Polar bear in sight ! "—" Wonderful keen eyes he must have," I thought ; for gaze as I would at the ice-floes towards which he had pointed, I could not see a trace of a polar bear. In a

moment we were skimming over the piled-up ice-floe, and then I realised that Neumann, had shouted "iceberg," not "polar bear," [1] thinking that some film pictures of this would be interesting. We laughed heartily over the little misunderstanding, as we winged onwards and upwards towards the Norwegian Islands, along whose western shores a huge fog-bank was drifting. (See Fig. 35.)

At 4 p.m., from a height of 1,500 metres (4,920 feet), I was looking down into Virgo Harbour in Dane Island. Here are still to be seen the ruins of the huts of Andrée and Wellman, the balloonists. An account of these two aeronauts' attempts to reach the North Pole has already been given by my colleague, Professor Wegener. While Wellman was engaged upon his great advertising stunt, Dr. Cook, a past master in the same art, had come back from Greenland to announce his discovery of the North Pole—since then, of course, utterly discredited. A few days after Cook's sensational declaration, came the report that Peary, who had some years before attempted without success to reach the North Pole, had at last been able, on April 6, 1909, to raise the Star-Spangled Banner upon that northernmost point of the ice-field where all the meridians intersect. But Peary's aim had been

[1] In German the words are respectively "Eisberg" and "Eisbär."

the establishment of a sporting record, rather than the advancement of science.

The fog, which just after starting we had noticed far out on the western sea, had now drifted in to the coast, so that we could no longer fly southward over the water. After passing to the north-westward of Fowl Bay, with its wonderful glaciers and its background of mountains (see Figs. 23 and 24), we took from Smeerenburg Bay a direct overland route to Cross Bay, across the mountains of the Reusch Peninsula.

Hitherto there had been little sign of the abundant arctic fauna. I had merely caught sight of a few seals, basking on the ice-floes, when we were flying low in Broad Bay. Now there was a change in the picture. From the cliffs of the main island and from the rocky islets, there rose vast numbers of northern sea-birds, gulls for the most part, alarmed on the breeding grounds by the thunder of our engine, and obviously regarding us as some new and terrible bird of prey.

We were now flying due south, at an altitude of 1,500 metres (4,920 feet). Once again I had the impression that I must be amid the familiar Alps of Berne or Valais, so close was the resemblance to these shown by the gneiss and granite peaks lying between Smeerenburg Bay and Cross Bay. From the huge Lilliehook Glacier, seven

derivative glaciers streamed westward in parallels to the sea, declining steeply, and their extremities vanishing into the invading wall of fog. At 4 p.m. we passed the long knife-edge of crystalline schistous rock known as King Haakon Mountain, which divides the northern end of Cross Bay into two fjords. Between Cross Bay and the sea lies Diesel Peninsula, split up by small glaciers in the ravines into a finely-chiselled relief—the contrast effects being heightened by vestiges of unmelted snow. (See Fig. 48.) On the landward side of this most beautiful of fjords, the dark and steep slopes of Hecla Hook and its gleaming glaciers descend from a height of 1,300 metres (4,260 feet) into the gently rippling greenish-blue waters.

The next two hours brought the necessary release of nervous tension. The air was calm. The engine continued to emit a monotonous iron-toned note, and went on working satisfactorily. Our goal was already visible in the southern distance; moreover, we were now in the neighbourhood of the more frequented parts of Spitzbergen. There were smooth glaciers beneath us, and had we been forced to land upon one of them we could, in a few days, easily have made our way on skis to the mining station in King's Bay.

The sun was warming the cabin pleasantly. Most of the work was done, and I could give

myself up to the enjoyment of the wonderful scenic charm. Out of a cloud-stratum flowing like a golden river over the western sea, projected a huge crest running north and south—the apparently unapproachable crystalline peaks of Prince Charles Foreland. But these did not form our horizon in that direction, though they were the last mountains on Spitzbergen's coast. Far beyond them stretched the cloud-pall and the sea, away towards Greenland. Never before had I been so overpowered by the spell of remote oceans and far-flung lands, full of unearthly beauties and magical wonders. I felt as if I were a mighty king, a conqueror with overwhelming forces at his disposal—the tamed energies of nature which impelled our metal bird upon its impetuous course. Had I been down there on the surface of the waters, down there on the glaciers or the peaks, I should have been a mere homunculus: subject to all nature's caprices; cribbed and confined within the encircling landscape; tied to the rough and wrinkled earth; crippled by the force of gravitation. But now I could snap my fingers at that crippling force, I had freed myself from that burden, and, untrammelled, no longer earth-bound, could rejoice in these vast outlooks from heaven over the lands and the seas. What an entrancement!

Yet, even as I looked forth exultantly, other pictures rose in the imagination. I fancied

myself flying once more over the charming green valleys, the familiar châlets, the mountain villages, of my native Alps. Home-sickness was pulling gently at my heartstrings, the home-sickness from which the Swiss are never exempt, the yearning that unceasingly summons them back from afar. We all have it, this unappeasable longing for the quiet corners of our mountainous homeland. In me, it now became vocal, saying: "Only in the shadow of the Alps can you find peace. Here you will ever be consumed with a passion cradled in the foaming seas of the arctic, and brooding over the hilltops of the frozen north."

Looking southward from King's Bay, it seemed as if the fog had already made its way into Ice Fjord, and perhaps as far up as Green Harbour. In that case we should be unable to land there. Maybe Advent Bay would be still clear, if so we would land there, and await favourable weather before returning to Green Harbour. When a few days before, we had visited the Norwegian coalmining station in Advent Bay, the hospitable manager had been most cordial in assuring us of his desire to render us any assistance in his power, should necessity arise. From Advent Bay we could send a wireless message to Green Harbour, asking for help by boat. Well, half an hour would now decide the question for us. We left King's Bay to pass

above the huge King's Glacier and the Holtedahl Plateau, whose acquaintance we had made on the previous flight. I took a last glance westward, over the sea. (See Fig. 37.) The King's Glacier, much-crevassed, extends right down to the fjord, whose waters are for a considerable distance tinted brick-red by the fine sand carried down by the rivulets which, during the summer thaw, run over the surface of the glacier. In Brögger Peninsula, on the other hand, the glaciers have receded, so that they end a long way above sea-level. Here, and in a good many other parts of Spitzbergen, a casual glance is enough to show that there is a general tendency to recession of the glaciers, that the land is less ice-bound than of yore. The climatic conditions of the region are tending once more towards warmth. Millions of years ago, in the intermediate phases of the tertiary period, the district was covered with dense forest, and the climate must have been sub-tropical. Subsequently, the forests were submerged, layers of sandstone were superimposed, and in the course of long ages what had been wood was compressed into coal. The heat of ancient days, stored in a land where the climate has become so cold that no trees can grow, in a land separated from civilisation by the ice-covered arctic seas, is now being turned to account in far distant regions, and under very different skies !

We snatch a parting glance at the King's Bay mining station, conspicuous in the light of the westering sun through the yellowish sheen of the wooden hutments. "Have any of the miners seen us?" we wonder. Heard us, more likely; for we are far to the eastward of the settlement and are flying so high that we must be barely visible to the naked eye. From that distance, the airplane must look like a tiny bird.

In forty minutes' steady flight we crossed King Oscar the Second Land, and reached Ice Fjord once more. Now we could see that the entrance to Green Harbour was still free from fog. A few hours later, a landing here would have been impossible, for the thick weather had spread landward from the western sea. But our luck held. With eyes growing now somewhat weary, I took my last look on Spitzbergen from the upper air; and then, from a height of 1,800 metres (5,900 feet), we planed down to the water in front of the whaling station. It was 6.15. The circuit had lasted 6 hours and 40 minutes. We were both bubbling over with delight at the successful completion of the first extended flight ever made in the arctic. We had traversed one of the most interesting and beautiful among the mountain regions of the far north, and had taken a great number of photographs. The scientific value of our booty had yet to be determined.

But when, in due course, by the faint and eerie reddish light of the dark-room lamp, the images of the scenes we had visited began to take shape in black and white, the memory of all that we had seen became intensified. What had been a past full of rich experience became a delightful present, filled with a longing for the northern seas, for the blue mountains and the gleaming glaciers of the frozen north—the age-long yearning of man towards the spotless dream-land vistas of Thule !

A Lame Duck.—Next day, when we awakened from a long and deep sleep, Green Harbour was wrapped in chill mist. Sluggishly the eider-ducks flew to the fjord from their breeding grounds in the tundra, and plumped heavily down on to the water. How gloomy the weather seemed, how leaden was the weight it laid upon our spirits ! The exultation of yesterday's flight had vanished. Now I could think only of the naked poverty of this country, of the forlornness of its landscape wreathed in fog. These variations of mood, light and dark in unending alternation, seem to affect the countryside no less than the minds of men, thus mirroring the profound mysticism of the northland.

But to-day we must turn from these dreamings to a practical task ; we must learn the reason for the unsatisfactory working of the engine

again and again during the flight. This did not take long to ascertain. Magneto I. was at fault; the interrupter was defective; the ignition of plug-series I. was permanently in abeyance. The whole flight had been made upon the ignition provided by one magneto only! In Spitzbergen, unfortunately, there was no possibility of repairing the defective magneto, for the requisite appliances were not forthcoming. The only chance was (since, in the haste of our departure from Germany, we had omitted to supply ourselves with a spare magneto) that what we needed might be requisitioned from one of the four coalmines in Spitzbergen. Enquiries could be made by wireless. Meanwhile, Neumann, having reduced the load of the airplane to a minimum, made several attempts to rise. They were fruitless. Owing to the faulty ignition, the engine could not develop sufficient lifting power to overcome the adhesive force of the water.

Our last hope was in the mines, but, during the afternoon, replies in the negative were received from every one of the four wireless stations. No magneto was obtainable in Spitzbergen. Had we sent a wireless message to Norway, from three to four weeks would have elapsed before we could hope to have what we so urgently required delivered by steamer in Green Harbour. But there were several reasons against staying all that time in the far north, so we reluctantly

determined to return home a few days hence in the collier now being freighted.

Thus collapsed all the far-reaching expectations which the success of the previous flights had seemed to justify. Dolorously I contemplated the five intact barrels of petrol, an amount of fuel which would have sufficed for flights lasting at least twenty hours. We could have done so much with this provision. We could have flown 2,500 kilometres (more than 1,500 miles), for the most part over regions hitherto unsurveyed! What had already been achieved seemed to me no more than a good beginning; a storing of experience thanks to which we should have been able to secure far more signal results, and to give an even more convincing demonstration of the supreme value of the airplane for geographical exploration. My hopes of doing great things were dashed when they had seemed at the point of realisation. The blow was a severe one, and I cannot say that even yet I have fully recovered from my disappointment. I have been unable to shake off the sense that our work was left in a half finished state, and that is why my friends have found it hard to persuade me to publish my daily jottings in the form of this little book.

What we had above all intended to study during our projected long flights were the problem of navigation when crossing the great ice-field, and the problem of landing on the ice-pack. In

addition, should the weather conditions have been all that could be desired, and should the engine have been in perfect order, we had planned to fly due north as far as the 85th or 86th parallel of latitude and back again. Our guides in this navigation across the great ice-field would have been the sun, a chronometer marking Greenwich time, and our driftmeter. We should have taken turns in the pilot's seat. Another interesting investigation would have concerned the nature of the surface of the ice-pack, and the relative distribution of ice and open water in these high latitudes. Here photography both from high altitudes and from close to the surface would have been of great value.

Peary, in his forced marches to the North Pole and back, found large stretches of smooth ice, recently formed on what had been leads in the ice-pack. But this was in early spring. Perhaps at midsummer we should find very different conditions. I burned with eagerness to fly in a trustily-engined airplane across the ever-changing ice-field, that I might see for myself, from an outlook enormously superior to that which any one else had hitherto enjoyed, what conditions actually obtained in this region—might study them with the new and vastly improved method furnished by modern science. The data thus acquired would have been of inestimable service for the intended subsequent flight to the North Pole.

Another plan was to fly round the east coast of Spitzbergen and North East Land, examining various unknown regions, and in especial making a detailed study of Stor Fjord or Wybe Jans Water and the Thousand Isles between Edge Island and West Spitzbergen. This is a region where the cold current moving southward from the Pole is laden with huge ice-floes throughout the summer, so that even at that season navigation is perilous.

Although these ambitious schemes had to be abandoned, we had still to wait a week until the steamer was ready to sail. On four days during this week the weather was bright and beautiful, and I passed the time in hill-ascents and ski-touring in the neighbourhood of our quarters. The airplane was hopeless. On July 15th, when the steamer hoisted the Blue Peter, Neumann could not use the air-route for the short stretch from the wireless station to the coalmine. Our lame duck could not rise from the water !

ENVOY

By evening everything was aboard, and we had exchanged farewell greetings with the kind friends we were leaving in Spitzbergen. At 2 a.m. on the 16th, the "Ameland" weighed anchor, and, heavily laden with coal, steamed slowly down the fjord. The midnight sun, as if to wish us goodbye, peeped out from behind the clouds as we took the last sight of a place that had become dear to us. The blue fjord of Green Harbour with its rivers of ice in the background, the bold flanks of the Alkhorn above the entrance to Ice Fjord, and the defiant rocky crest of Prince Charles Foreland ruddy in the rays of the eastward-moving sun—all of these, receding into the distance, seemed to wave us adieu.

In a few weeks, in a few days, we had, thanks to the airplane, become intimately acquainted with one of the most beautiful and interesting regions in the Polar Sea. Despite our crowning mishap (the failure of the magneto), the expedition had as a whole been under a lucky star. Thankful, therefore, for what we had been able to achieve, we left the lonely island of the far north in the hope to return thither at no distant date. Once again, it may well be, we shall fly over the mountains, glaciers, and fjords of Spitzbergen.

SKETCH-MAP OF LOMME BAY COMPILED FROM PHOTOGRAPHS NOS. 38, 39 AND 40.

BOSTON PUBLIC LIBRARY
3 9999 09873 258 7

By Airplane Towards the North Pole

AN ACCOUNT OF AN EXPEDITION TO SPITZBERGEN IN THE SUMMER OF 1923

By

WALTER MITTELHOLZER

AND OTHERS

THIS account of an expedition by a famous Swiss aviator, accessory to Amundsen's attempt to reach the North Pole by airplane, contains a very lively and well-written account of adventurous experiences and presents an extraordinarily interesting description of Spitzbergen. The book is scientific but not technical, and will appeal alike to the expert and to the general reader. A feature of particular interest is the forty-eight superb reproductions of photographs of Arctic scenes.

HOUGHTON MIFFLIN COMPANY